POWER PLANT ENGINEERING

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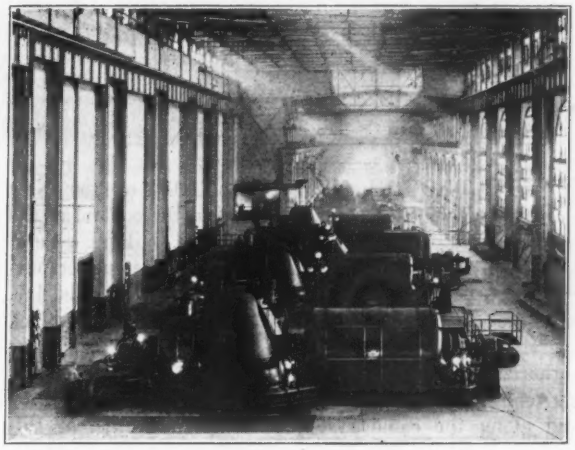


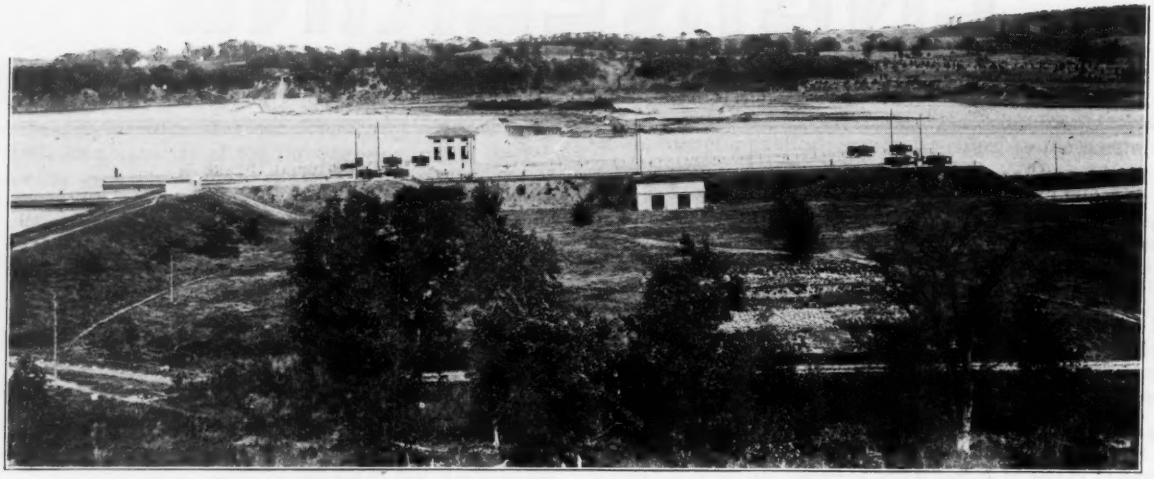
When a Unit Needs a Friend

IF THE SLEEK, well groomed turbo-generators in the foreground of this picture were capable of expressing emotions we might assume that their feelings would show up as a smug complacency in the contemplation of their position in the limelight. On the other hand, the older units, in the hazy background, would be filled with reminiscences of the good old days when they too basked in the spotlight of attention. But a friend of the older and less efficient units arises. M. K. Drewry, on page 887 of this issue, points out that in the interest of overall station economy there are a lot of things to be taken into consideration when loading units. So don't be contemptuous of the units which have an efficiency seven or eight per cent less than the new units; they may yet help you in the battle to keep the coal bills down.

OF WHAT USE could an old abandoned stone quarry be but to provide a first class swimmin' hole for the kids? Probably none that is better for the health of the community but we find now that there is another which is more profitable. In the Letters Department of this issue there is an account of how an old stone quarry, situated close to a growing central station, was bought and pressed into service, supplying cooling water for the condensing apparatus in the power plant. By making use of this advantageously located pond the plant has been able to increase its output tremendously. Now we may look for progressive engineers to advocate the quarry bank as an ideal location for power plants.

Power Developments on the Barge Canal

Two 8000-hp. Waterpower Plants Now Under Construction.
Power for Lock Operations Supplied by 32 Small Plants.



ALTHOUGH THE CREATION of the New York State canal system and the control of the water supply have necessitated building several dams which could be used for water power purposes, not much has been done along this line, with the exception of the small plants required for lock operation. In the year 1922, however, the legislature authorized the Superintendent of Public Works to extend and enlarge the existing development of water power on and along the canal system. As an outgrowth of this legislation $1,000,000 was appropriated for the construction of power plants at the barge canal dams located at Crescent and Vischer Ferry. At each of these sites it was estimated that an economic development of 8000 hp. was available. The original plan called for the development of 5000 hp. at each of these sites, although the plans have since been changed.

To permit the development of an 8000 hp. plant at each site, an additional appropriation of $710,000 was made by the legislature in 1923. The work on these plants is now under way and it is expected that both of them will be completed by the early part of 1925. In order, however, to get an idea of the scope of the engineering features involved in the development of water power on the barge canal, it is essential to have an historical background, which will give an idea of the early developments.

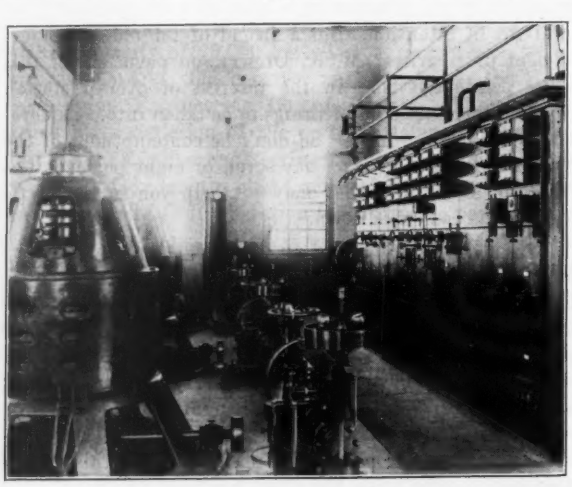


FIG. 1. PRESENT HYDROELECTRIC PLANT AT THE CRESCENT DAM SUPPLIES POWER FOR FIVE LOCKS AND TWO GUARD GATES

Work on the old Erie Canal was started in 1817 and in 1825 the first two branches, the Erie and Champlain Canals were completed. Then began a period of such unexpected success in the canal venture that five lateral canals were built by the State and two by private companies and the first enlargement of the Erie Canal was begun, all within a decade.

Canal Rebuilding Begun in 1903

The years 1835 and 1862 were respectively the beginning and ending of the first canal enlargement. After 1862 the developments of the state canal proceeded more slowly, and it was not until 1903 that the voters of the State of New York were called upon to decide whether the entire canal system should be rebuilt. It was decided at that time that an appropriation of $101,000,000 would be made available for the purpose of improving the Erie, Oswego and Champlain branches. As a result the barge canal as shown in Fig. 3 now takes the place of these canals.

For a good part of the distance the present canal system is made up of canalized rivers, with the proper regulating works for the control of the flow. This fact in itself is quite important in the consideration of water power developments, since the regulating works necessary for water storage and flow control can be utilized not only for this purpose but also for the purpose of producing power.

Water is required in operating a canal for six main purposes, namely: to fill the canal prism; to fill the lock chambers; to provide power for operating lock machinery; to provide power for lighting the vicinity of the locks; to replenish loss due to unavoidable leakage through gates, culverts and turbines at locks, and to replenish loss in the levels between the locks.

In discussing these purposes, it may be said that an independent water supply for filling the canal prism is needed only in land lines and then only at the opening of navigation or after water has been drawn from the levels for some reason, such as making repairs. In river lines the natural flow of the stream will of course fill the prism. Next in importance to filling the canal is the use of water for lock operation.

Source of Water Supply

This water supply for the improved Erie canal is derived mainly from three sources: 1st—By water which is drawn from the Niagara River, which is tapped at Tonawanda and flows east to Three Rivers and into the Oswego riser. 2nd—From a reservoir which has been created a short distance north of Rome and which is known as the Delta reservoir, and 3rd—From another reservoir some 25 mi. east of the Delta reservoir which is known as the Hinckley reservoir. By referring to Fig. 3, the location of these reservoirs in respect to the improved Erie canal will be noted. The summit level of the Champlain canal is fed by the Glens Falls feeder canal from the upper reaches of the Hudson River.

At the Delta reservoir the waters of the upper Mohawk River are controlled by a dam 1100 ft. long with a spillway 300 ft. long near its center. Its height is 100 ft. from crest to lowest foundation. The reservoir has an area at crest level of 4⅓ sq. mi., a maximum depth of 70 ft., an average depth of 23 ft. and a capacity of 2,750,000,000 cu. ft. The area of the tributary watershed is 137 sq. mi.

At Hinckley the waters of West Canada Creek are impounded. The dam has a total length of 3700 ft., of which there is a 400-ft. masonry section, and an earthen portion which has a concrete core running through most of its length. The reservoir forks into two parts which have a combined length of about 13 mi., with a width of about a half mile. Its area is 4.46 sq. mi. and its capacity 3,445,000,000 cu. ft. The maximum depth at crest level is 75 ft. and the average depth 28 ft. The topography of its water shed of 372 sq. mi. is rugged and the altitude varies from 1165 to 3100 ft. above sea level. A study of Fig. 3 will show that the water of the Hinckley reservoir is conducted to the Erie canal through a part of West Canada Creek, thence through a diverting channel about 5.7 mi. long, to Nine Mile creek and into the canal.

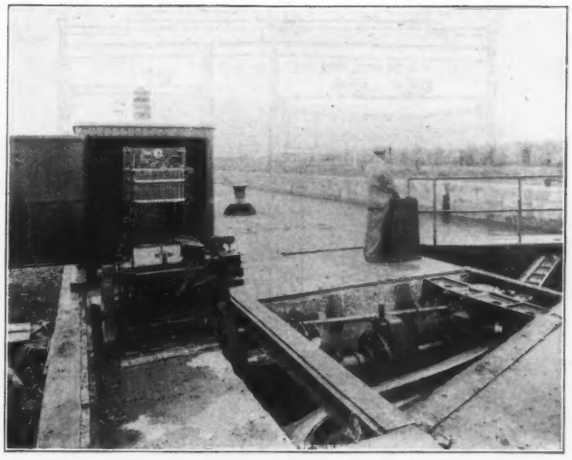


FIG. 2. GATE OPERATING MACHINERY AND MASTER CONTROL STAND FOR ONE OF THE LOCKS

These three main sources of water supply furnish the water for operating the Erie canal and the various dams which have been built in the rivers which make up part of the canal in order to control the stream flow and make these sections navigable.

Main Function of Dams Is Water Control

There are four dams of a fixed variety on the Barge canal which are outstanding because of their size. Two are river dams located in the lower reaches of the Mohawk, and two are reservoir dams. The dam at the lower end of the Mohawk River navigation, called Crescent dam, is situated just below the point where the land line from the Hudson enters the Mohawk. This dam is curved in

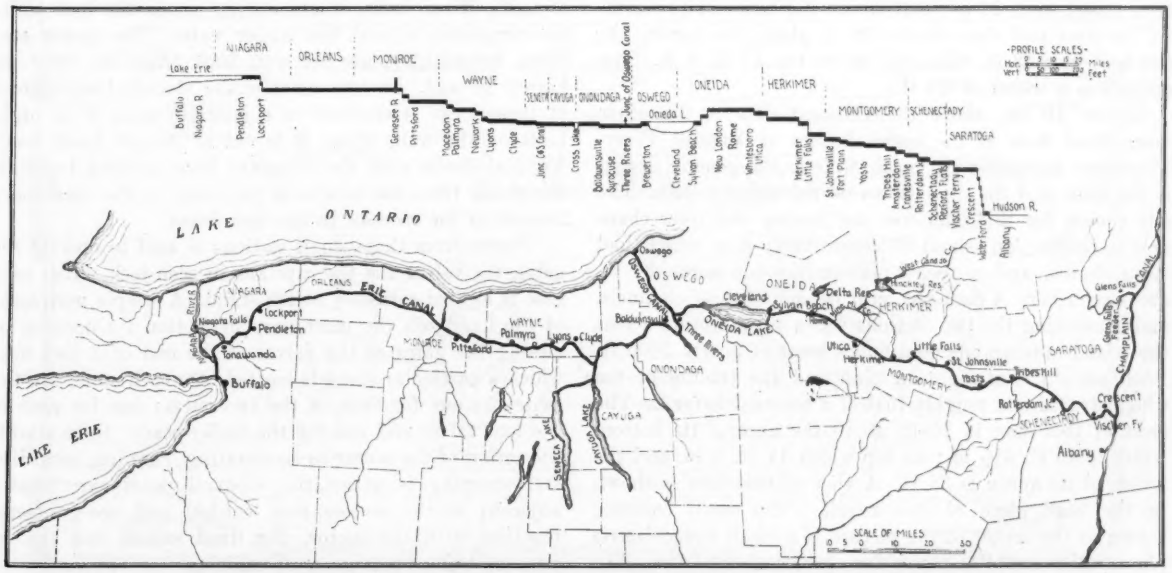


FIG. 3. ERIE BRANCH OF THE BARGE CANAL IS SUPPLIED WITH WATER FROM THE NIAGARA RIVER AND THE DELTA AND HINCKLEY RESERVOIRS

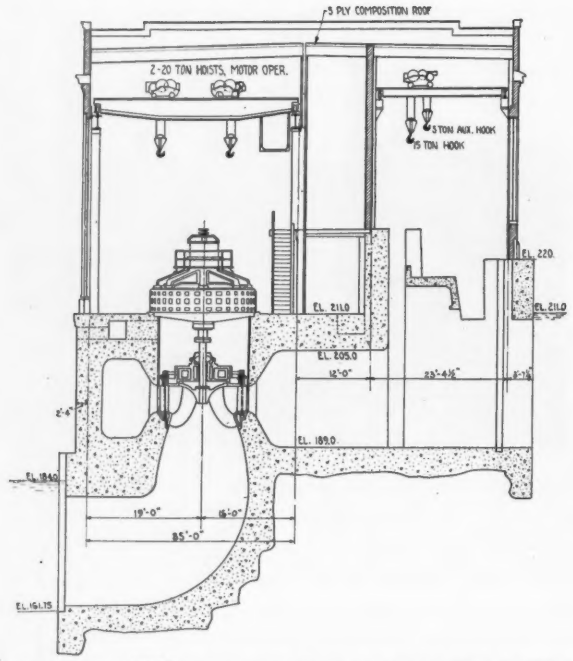


FIG. 4. TWO 2800-KW. UNITS WILL MAKE UP THE INITIAL INSTALLATION AT CRESCENT AND VISCHER FERRY

plan, but is of the gravity type, not depending on its curved form for stability. The structure, as will be noted from Fig. 7, is made up really of two dams with a rocky prominence intervening. One section spans the former river channel, while the other crosses low land which after completion was submerged. The entire structure sweeps through a semicircle on a 700 ft. radius with a total length of 1922 ft. Across the front of the dam, built on the low land, was constructed a third dam. This is lower in elevation and its purpose is to maintain a pool which may serve as a water-cushion to break the fall of water over the crest and to prevent erosion of the rock at the foot of the main dam. The pool back of the main dam has been raised some 27 or 28 ft. above the former river level. At its crest this dam stands 39 ft. above the apron. At the base it is 42 ft. wide and at the top 11 ft. 5 in. The apron has a width of 40 ft.

About 10 mi. above the Crescent dam is the other large fixed dam of the canal, known as Vischer Ferry. These two structures are much alike as the general design is the same and the dimensions do not differ widely. The site chosen for this dam was one having two river channels encircling an island of considerable size, which had steep shores, and a rocky plateau-like top some 20 ft. above the river. A dam was built in each of these channels, and connecting the two sections was a third section across the island making one continuous crest of nearly 2000 ft. Each section is straight in plan and the tracing of the whole structure is roughly that of a reversed letter Z. The crest of this dam is 36 ft. above the apron. Its bottom width is 40 ft. 6½ in.; its top width 11 ft. 5 in. and the width of its apron is 38 ft. A view of this dam is shown in the head piece of this article. The small building shown in the center of the picture is a small hydroelectric plant which supplies power for operating the locks. The new plant is under construction at the opposite end of the dam.

In addition to the two 8000-hp. plants under construction at Crescent and Vischer Ferry there are a number of small developments on the Barge canal which are utilized in the operation of the locks. In general each Barge canal lock has its power plant. There are 31 direct current-electric stations and 11 direct current gasoline-electric stations. There is also one alternating current hydro-electric station which serves five locks and two guard gates which is located at the Crescent dam and which will be superseded by the new plant which is now being built at that site. At a few locks power is purchased.

Equipment in the Lock Plants

Of the 31 direct current hydro-electric stations mentioned, 26 of them have vertical shaft generators and 5 have horizontal shaft generators. The equipment at one of the vertical shaft type consists of two head gates, two Francis inward-flow turbines, each directly connected to a 50-kw., 250-v. direct current generator, a switchboard consisting of two generator panels and one feeder panel; two motor driven governor oil pumps, two oil pressure governors, a motor driven oil pump and lubricating system, a traveling crane, four 4000-w. electric heaters and a lighting system. At certain locks, slight variations occur. If a station feeds more than two locks, the capacity of the generator is increased to 75-kw. and an extra feeder panel is added. If the second lock is less than a mile and more than a half mile distant, a booster set is provided, together with the necessary switchboard panel.

Where the head of water is so low that the turbine speed falls below 150 r.p.m. horizontal shaft generators running at a full load speed of 300 r.p.m. are connected to the turbines through bevel gearing. At the locks beside which are movable dams, the power stations are of the gasoline electric type. The movable dams are generally raised at the close of the navigation season, thus destroying the head of water and precluding its use when needed for lowering the gates. At each of these locks, therefore, there has been built a station having two 25-kw. gasoline electric generator sets, with a closed cooling system and incidental electrical apparatus. Eight of these stations are at Mohawk River locks, where during floods the lock walls are sometimes several feet under water. The power stations, accordingly, are set well back from the river on higher ground. In like manner the electrical equipment of these locks is enclosed in a concrete cabin 9 ft. high, built on the wall, where it is out of danger from flood. Vertical shafts with the necessary bevel gearing transmit the power from the motors in the cabin to the machinery located in the recesses in the lock below.

Power from these small stations is used to operate the gates, the valves and the capstans in each lock. Near each gate is located a master switch stand. A simple movement of the hand sets the machinery in motion for opening or closing the gates or the valves at the end of a lock near which a particular stand is located. On each stand are five switches; one for each of the two gates; one for each of the two valves and one for the buffer-beam. Once started the action of the motor in accelerating, running, retarding and stopping is automatic. Control panels are located adjacent to the motors they control and are protected together with the motor, the limit switch and the resistance units by large steel cabinets.

Each gate is operated by a 7-hp. motor through a train of gears driving the vertical pinion, which meshes

with teeth cut in the face of a spar attached to the gate. Most of the gate machinery is in a recess below the top of the lock wall and is covered by checkered steel plates. The remainder, together with the electric equipment is above the lock wall, protected by the controller cabinet. On a lock having feed culverts of the 5 by 7-ft. or 6 by 8-ft. size a 3-hp. motor operates each valve. On high lift locks, having 7 by 9-ft. culverts, 7-hp. motors are used. A part of the valve machinery is also located in the recess in the lock wall and covered with a checkered plate, while the rest is in the cabinet on the back of the wall. At each end of each wall is placed an electric capstan which has a capacity of 8000 lb. at a speed of 60 ft. per min. The machinery and the 20 hp. compound wound motor for the capstan are enclosed in a water-tight, oil-tight case, so the equipment will escape damage even though it is submerged.

All of these small developments were made for the purpose of supplying current for operating the canal locks and no excess power is therefore available for distribution. In the case of the two present developments, the Crescent and Vischer Ferry, the idea is not only to furnish some power for canal operations, but also to sell the excess to any municipalities that may wish to avail themselves of this source of power.

Figure 4 shows a section view and Fig. 6 a plan view of one of the new power plants. Each plant is equipped with two 4000-hp. S. Morgan Smith Co. Francis type water wheels, driving General Electric Co. 2800-kw., 3-phase, 60-cycle, 2300-v. generator. The Crescent plant, however, has head works which are designed for two additional units.

Head gate operating machinery was also supplied by

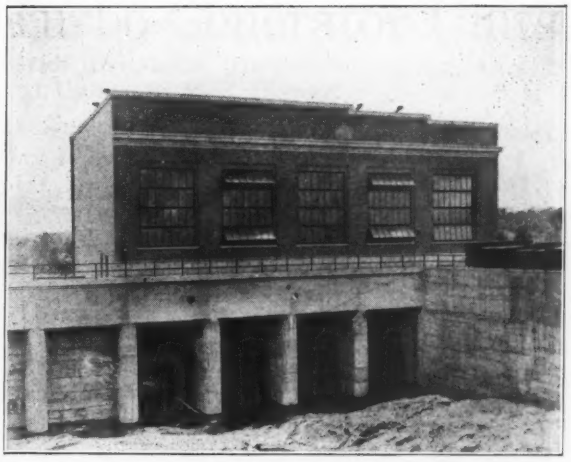


FIG. 5. FOUNDATIONS AND SUPERSTRUCTURE OF CRESCENT PLANT COST $335,000

the S. Morgan Smith Co., and consists of two Stony gates for each unit, each gate having two rising stems operated by a 13.2-hp. motor which is connected to the two stems through gearing. As will be noted from Fig. 4, the trash racks are enclosed by the building and a crane is provided which may be used for removing the racks or for making any repairs on the head gates or operating mechanism.

S. Morgan Smith actuator type governors regulate the operation of the turbines and another feature of the installation is the use of compressed air for stopping the rotors or for jacking the rotors up for inspection or repairs.

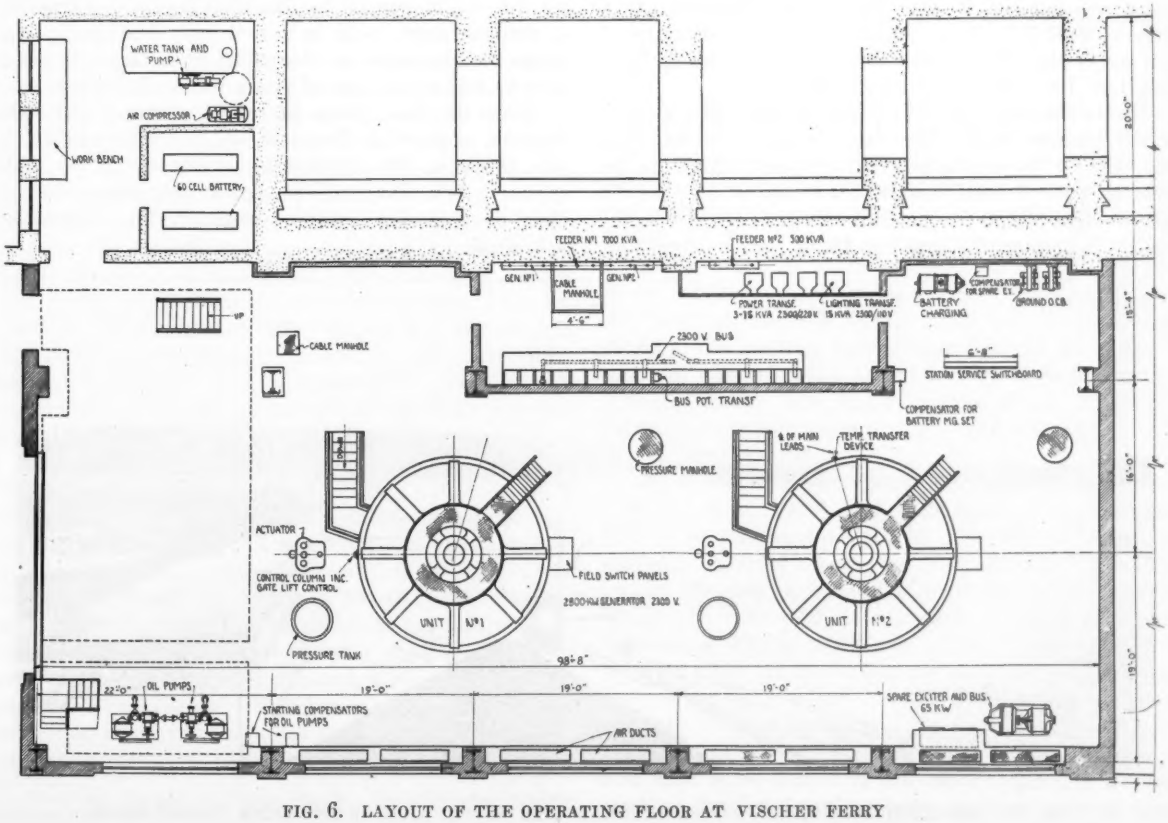


FIG. 6. LAYOUT OF THE OPERATING FLOOR AT VISCHER FERRY

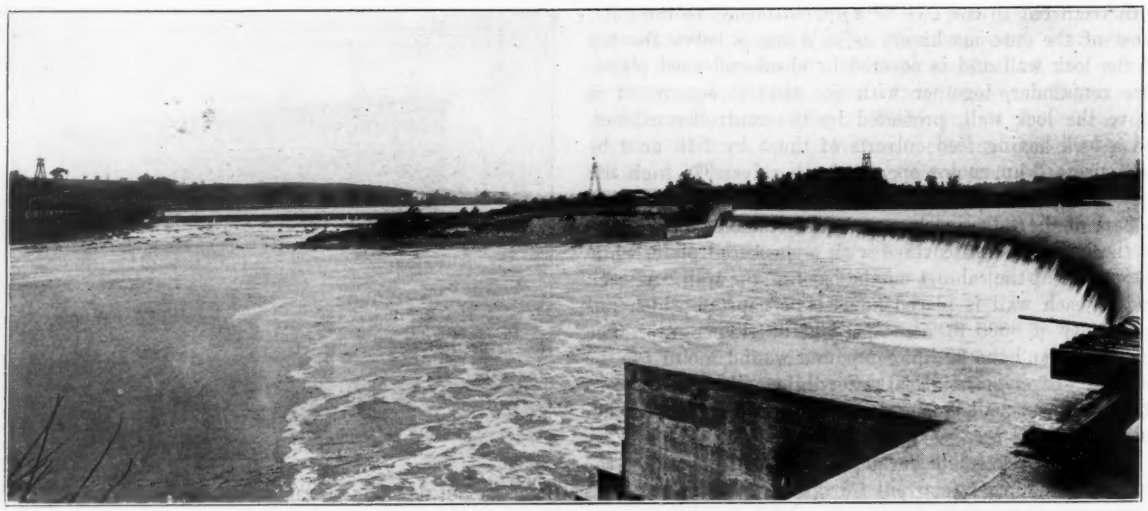


FIG. 7. DAM AT CRESCENT. THE POWER PLANT IS BEING BUILT JUST BELOW THE HEAD GATES AT THE EXTREME LEFT

A water tank and pump are provided for cooling the bearings and also for cooling the oil which is used for lubricating purposes. The units are also equipped with the General Electric type of coil spring thrust bearings.

According to the report of the State Engineer for 1924, the contract price for the four turbine units was $156,869.00 and the contract price for the generators and other electrical equipment for the two plants amounted to $235,713. The foundation and incidental work up to the first floor of the power plant at Vischer Ferry was constructed by the American Pipe & Construction Co., at a contract price of $196,655, while the super structure for this power plant was handled by the McCann Building Co., at a price of $143,567. The foundation and super structure of the power plant at Crescent was built by Brown & Lowe and Law Bros. at a cost of about $335,000.

From the sectional view it will be noted that 2 20-T. motor operated hoists have been installed for handling the parts of the turbine unit. The runners which are the heaviest part of these units weigh 45,400 lb. and the top plate weighs 33,700 lb. Another feature of interest in the design is the use of a cast iron lining for the wheel pits. Units are designed on a basis of 26.5 ft. head and under normal operating conditions the head will be 27 ft. At the gate opening of 93 per cent maximum efficiency is guaranteed to be 89 per cent and it is expected that the wheels will show about 91 per cent in operation. Each generator is equipped with a direct connected 60-kw. exciter. One motor generator set rated at 65 kw., 1200 r.p.m., 250-v. is provided as a spare exciter.

When the legislature authorized the building of these plants no provision was made for the transmission lines to carry the current to any of the prospective purchasers as it was planned to sell the surplus power at the switchboard to the highest bidder. In 1923 the act was amended so that the power could be sold to such municipalities as might wish to utilize it. According to the Act this power is to be sold at the cost of production and delivery.

Plans for these plants have been prepared under the direction of the State Engineer, and in the preparation of this article we are indebted to Dwight B. La Du, state engineer; A. G. Chapman, deputy state engineer, and C. H. MacCulloch, senior assistant engineer, for information furnished.

FIG. 8. HINCKLEY DAM WHICH CONTROLS THE WATER SUPPLY EAST OF THE ROME SUMMIT LEVEL

Economical Loading of Turbo-Generator Units

PRONOUNCED TURBINE CHARACTERISTICS DEFINITELY DETERMINE MOST EFFICIENT OPERATION OF SEVERAL UNITS. BY M. K. DREWRY*

SINCE THE NEWER and larger units installed in modern power stations are appreciably more efficient than the original units they supplement, one's first thought is that these more economical units be operated at their full load point, thus supposedly generating the maximum amount of energy at maximum efficiency. Such operation, however, may be very inefficient, in some cases, causing a thermal loss of two per cent on the entire output as later examples will show.

The turbine water rate curve, because of thermodynamic processes attendant with turbine governing, is decidedly different from the conventional water rate curve

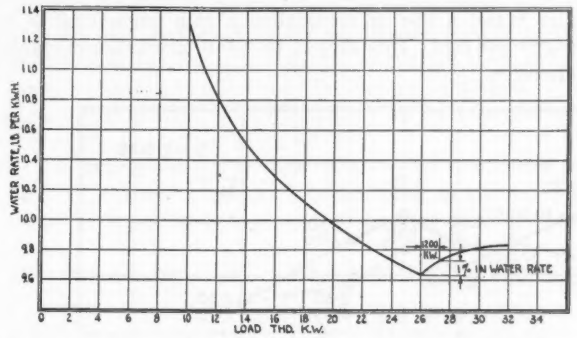


FIG. 1. CHARACTERISTIC WATER RATE CURVE OF A THROTTLE-GOVERNED TURBO-GENERATOR UNIT, SHOWING ABRUPT CHANGE IN ECONOMY AT OPENING OF OVERLOAD VALVE

of steam engines. Ordinarily, turbine economy is specified at three or four loads, and if plotted, the specified water rate points will generally fall upon a smooth curve not unlike the steam engine rate curve. If the unit is tested, however, at different loads, decidedly different results will be obtained than are ordinarily plotted.

Major variable turbine losses are almost purely straight-line throttling ones, reaching a minimum just before the overload valve opens, then increasing rapidly and finally gradually diminishing as maximum loads are carried. Other losses are either strictly or nearly straight line in nature, and being in themselves small, their influence of causing non-linear characteristics when added to the straight line throttling losses is too small for practical consideration.

The turbine Willans line of Fig. 2, which tests and analysis prove to be composed of two lines accurately straight for all practical purposes, can be transposed into a water rate curve only of characteristics as shown in Fig. 1. A positive intercept of the portion of the Willans curve below its abrupt change in direction (which represents opening of the overload valve) means that the rate curve will be initially concave upward; the negative intercept of the full load section means a concave-downward rate curve past the overload valve opening. To draw the theoretical curve from manufacturer's guarantees requires previous construction of the Willans line; then any point on the water-rate curve may be obtained with accuracy. Due to imperfect operation of some overload valves, the sharp rise of the rate curve past the most economical load point may be accentuated but in any case the following analysis holds.

*Technical Engineer of Power Plants. The Milwaukee Electric Railway and Light Co.

DIVISION OF LOAD AMONG UNITS

An analysis of most station loading will show that the large, most efficient units of a power station should always be operated with their overload valves closed, unless by

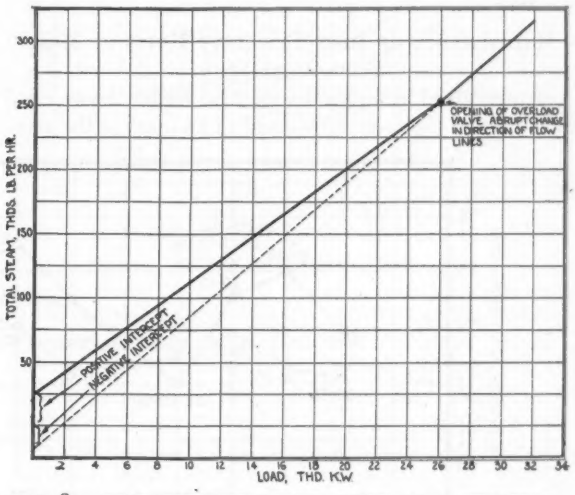

TOTAL STEAM, THDS. LB. PER HR.
LOAD, THD. K.W.
OPENING OF OVERLOAD VALVE. ABRUPT CHANGE IN DIRECTION OF FLOW LINES
POSITIVE INTERCEPT
NEGATIVE INTERCEPT

FIG. 2. CHARACTERISTIC FLOW CURVE OF A THROTTLE-GOVERNED TURBO-UNIT

their overloading, other units need not be started nor kept in service at low loads. Such large units may be several per cent more efficient than the smaller units and first thought may suggest that they carry all load possible, but the fallacy of such assumptions is illustrated arithmetically in Fig. 3.

An installation of two 30,000-kw. units and two 20,000-kw. units carrying loads from 35,000 to 100,000 kw. has been assumed for the example. To exaggerate conditions in proving that most economical units should not be overloaded, however greater may be their economy than the smaller ones, the efficiencies of the 20,000-kw. machines have been assumed 7 per cent poorer than those of the 30,000-kw. units.

Regardless of the exaggerated efficiency difference, the curves show that curtailing the output of a 30,000-kw. unit to its most economical load of 26,000 kw. when the station is carrying 40,000 kw. gives about 2½ per cent greater efficiency than allowing it to carry full load (4000 kw. more) because of its individually greater efficiency. Likewise at 45,000 kw. a gain exists, though only of 1 per cent since the 20,000-kw. unit must be loaded above its most economical load to allow the maximum number of kw.-hr. to be generated at minimum cost on the 30,000-kw. unit. At 50,000-kw. station load, however, the large unit must be overloaded in preference to starting a third machine, for the throttling losses of three units at that

load are about three-fourths per cent greater than those of two machines even though both of the latter lose two per cent in throttling through their overload valves.

At 65,000 kw. again is stressed the importance of not exceeding the most economical loads of the large units but at 75,000 kw. division of load makes little difference in plant economy from a loading aspect. Continuing upward to the plant capacity of 100,000 kw. another cycle of loading is passed, with similar though less exaggerated results. Neglecting variation of vacuum with turbine load and other minor influences which must be studied for each installation, one may state as a cardinal loading rule that all large, most economical units must always be kept at their most economical load unless overloading them can eliminate the operation of another unit at an extremely low load.

Maintenance of Most Efficient Units of Most Economical Load

Unless aided by an arrangement to render the overload valve gear of the most economical units inactive the accurate retention of most economical loads on those units is difficult. Fluctuating loads influence the governors of all machines, and each fluctuation either may mean unnecessary throttling loss or the expenditure of added effort in operation.

To disconnect the overload valve gearing for economical loading but still to allow the operator to rapidly put the gearing into active service for overloading, a variable length linkage piece has been found successful. Differential threading of a hand-wheel screw allows the link to be changed in length, thus rendering the overload cam powerless in lifting the overload valve. Once the most economical load is assumed the unit may be placed "on the throttle," its governor acting no more than an overspeed stop in case the load suddenly drops a considerable amount. The load carried will vary only with changes in steam pressure, superheat, and vacuum.

A slight additional gain will be realized in diminishing the throttling loss through the governing valve, which loss is ordinarily necessary for desirable speed regulation at the point of overload valve opening.

In this connection the recent reversion to initial hand-operated overload-valve design, as supplied on larger units of one manufacturer, is interesting. As in the first machines made by that company, no provision is made on the new machines for carrying overloads automatically. The operator must open the overload valve manually, thus causing him to realize that considerable economy is forfeited each time such action is necessary.

Summary

A detailed study of load diversion is warranted because of the fact that the turbine water rate curve is not a flat one; as a matter of fact, it has a marked minimum point from which departures in load rapidly cause considerable throttling losses. Under certain conditions the shifting of a few thousand kilowatts from one machine to another may entail a loss or accomplish a gain amounting to a couple per cent. This subject therefore merits considerable attention.

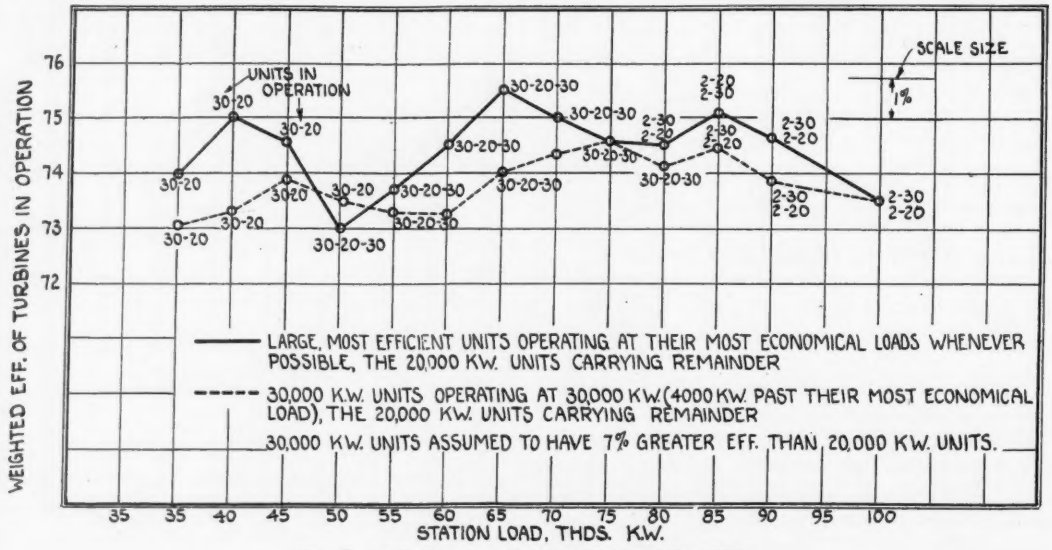

WEIGHTED EFF. OF TURBINES IN OPERATION
76
75
74
73
72
UNITS IN OPERATION
SCALE SIZE
1%
30-20
30-20-30
2-30
2-20
LARGE, MOST EFFICIENT UNITS OPERATING AT THEIR MOST ECONOMICAL LOADS WHENEVER POSSIBLE, THE 20,000 KW. UNITS CARRYING REMAINDER
30,000 K.W. UNITS OPERATING AT 30,000 KW. (4000 KW. PAST THEIR MOST ECONOMICAL LOAD), THE 20,000 KW. UNITS CARRYING REMAINDER
30,000 KW. UNITS ASSUMED TO HAVE 7% GREATER EFF. THAN 20,000 KW. UNITS.
35 35 40 45 50 55 60 65 70 75 80 85 90 95 100
STATION LOAD, THDS. KW.

FIG. 3. DIVISION OF LOAD AMONG TURBO-UNITS

Showing weighted efficiency resulting when following the two policies of dividing load as outlined above. Station equipment, two 30,000 kw. units, two 20,000-kw. units.

Installation of a load limiting device to maintain the large most-economical machines of a power station at their most economical loads may cause a two-fold gain in economy and a saving in operation attendance.

When used at high temperatures deterioration of thermocouples with age is unavoidable, and the higher the operating temperature and the more unfavorable the operating conditions, the more rapid the deterioration. Oxidation of the wire, contamination of it by oxidizing and reducing gases, cause the emf of the thermocouple to drop off, with the result that the pyrometer reads in error. Unless very high temperatures are used, however, months are required to cause large errors in a thermocouple. It is recommended, therefore, that pyrometers used for processes requiring accurate temperature measurements should be frequently checked. For example, base-metal thermocouples constantly used above 1800 deg. F., should be checked about once a week.

Effect of Vacuum on Overall Efficiency

OPERATING EFFICIENCY IS INFLUENCED BY THE HEAT SUPPLIED TO PRIME MOVERS AND AUXILIARIES AND THE HEAT RECLAIMED. BY BENJ. F. ROGERS

IN THE OPERATION of prime movers, particularly of the larger size, the question as to the best point of back pressure for the efficient operation of the plant often comes up. This may or may not be at that vacuum giving the highest efficiency on the turbine itself. In order to determine the relative over-all efficiency of the operation it will be necessary to consider the relative change in the total heat requirements of all the equipment influenced by the change in vacuum.

This total heat requirement may be divided into three separate items: (a) the heat supplied to the prime mover; (b) the heat reclaimed in the condensate returns to the system, and (c) the heat required to operate those auxiliaries which will be affected by the change in vacuum. The air removal or vacuum pumps may or may not be affected, depending on the type of installation.

By taking operating data at different conditions of vacuum, separate curves may be built up on the varying values of these items and on the resulting sum of these values. Since the total sum of the three will be in direct ratio to the total heat supplied for current generation, it leaves only the application of the cost figures to transpose the resulting variable into the monetary value.

ANALYSIS OF HEAT TO PRIME MOVER AND AUXILIARIES

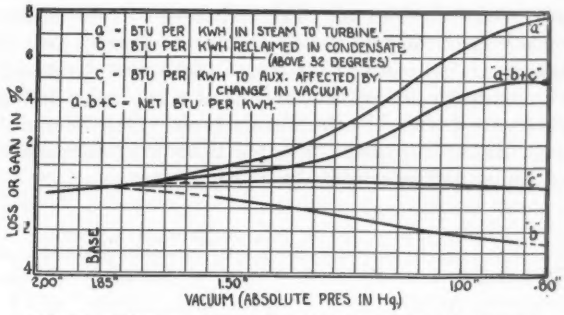
Test No.	1	2	3	4
Duration-hr.	1½	1½	1½	1½
Steam to turbine-lb.per hr.	199,972	206,775	202,629	189,377
Steam Pres.-lb. ga.	171	170	170	172
Steam Temp. deg. F.	528	518	525	548
Vacuum Temp. deg. F.	27.99	28.08	28.54	28.51
Barometer, In: Hg:	29.84	29.52	29.62	29.40
Hotwell temp. deg. F.	95	86	73	68
Condensate temp. deg. F.	106.4	96	84	80
Circ.Water inlet temp.deg.F.	47	46	44	43
Circ.Water Disch.temp.deg.F.	86	77	64	61
Load, kw.hr.	14,910	15,650	15,930	15,318
Steam per kw.hr. lb.	13.41	13.27	12.72	12.36
Absolute pres. In.Hg.	1.85	1.44	1.08	0.89
Steam per kw.hr. corrected to 170 lb. & 150 deg.superheat	13.42	13.23	12.72	12.47
Item (a) B.t.u. to turbine	17,187	16,945	16,282	15,969
B.t.u. gain	---	242	905	1218
Per cent gain	---	1.46	5.46	7.35
Item (b) B.t.u. returned to heater	999.9	849.3	661.4	593.3
B.t.u. loss	---	150.6	338.5	406.6
Per cent loss	---	0.90	2.04	2.45
Item (c) B.t.u.to Circul.pumps	376.3	334.4	351.1	372.0
B.t.u. gain	---	31.9	25.2	4.3
Per cent gain	---	0.25	0.15	0.02
Item (a-b+c) Total B.t.u. to turbine operation	16,563.4	16,429.7	16,971.9	15,747.7
B.t.u. gain	---	133.7	591.5	815.7
Per cent gain	---	0.81	3.57	4.92

As an example: It was necessary to determine the most efficient point of back pressure for the operation of a 20,000-kw. semi-double flow turbine, designed for 28 in. vacuum. The above method was applied, the operating conditions from which the curves were built up being taken at as near the high economy point on the turbine as possible. The data used represents averages of 10 readings, taken at 10-min. intervals, on a steady load.

All steam quantities were taken from flowmeters accurately calibrated and checked; the temperature readings were taken by standard chemical thermometers or the equivalent and condenser pressures were from direct reading mercury vacuum gages.

Variations in the load on the turbine were neglected in the water-rate correction, as the greatest difference in load noted caused a change of less than .02 lb. in steam per kilowatt, referred to the manufacturer's water-rate curve on this machine. Also, it was not considered advisable to separate the steam used for air ejector operation, since this is a constant and an inherent feature of this installation and the heat and resulting condensate is all thrown into the common condensate return to the heater.

The unusual result of the higher vacuum showing a lower steam requirement for the circulating pumps is due to the control of pump delivery by throttling the discharge. The tail-pipe discharge from the condenser carries a vacuum of 11 in. and as the pump discharge is opened, this vacuum becomes effective on the pump duty, decreasing the total head. The total head on the pump varies from 17 ft. at minimum load to 3 ft. at maximum load, and therefore the actual steam requirement is less at the greater delivery.


a - BTU PER KWH IN STEAM TO TURBINE
b - BTU PER KWH RECLAIMED IN CONDENSATE (ABOVE 32 DEGREES)
c - BTU PER KWH TO AUX. AFFECTED BY CHANGE IN VACUUM
a-b+c - NET BTU PER KWH.
LOSS OR GAIN IN %
BASE
2.00"
1.85"
1.50"
1.00"
.80"
VACUUM (ABSOLUTE PRES IN Hg)

CURVES SHOWING DISTRIBUTION OF HEAT TO PRIME MOVER AND AUXILIARIES

From the data at hand, there is no economic gain to be made by operating this turbine at less than 0.85 in. absolute pressure, even though the efficiency of the prime mover would be improved. In fact, if the operators followed the usual practice of carrying the lowest back pressure possible, the net result would, in this climate, be a loss in over-all efficiency during 6 or 7 mo. of each year.

Direction of Chain Drive Rotation

SUGGESTIONS as follows, based on good practice, are offered as a guide by the Ramsey Chain Co., for the installation of silent chain drives. Under ordinary conditions the slack strand may be either on the upper or lower side of the drive. This applies to drives where the line of center is horizontal or at less than a 45-deg. angle. Where the centers are comparatively short, slack on the lower strand is preferable. With the slack on the upper strand there is a tendency for the slack to be pushed out of proper engagement of the teeth of the driven sprocket.

Drives with comparatively long centers and small sprockets should be run with the slack on the lower strand. With the slack on top there is danger of the upper strand rubbing against the lower. Vertical drives should be avoided if possible. They must run fairly taut, which means frequent adjustment of centers, as the chain elongates due to natural wear. Less care and adjustment will be required if the drive can be placed slightly off the vertical. Generally speaking, such drives of steep centers should be run with the slack on the strand which is at the lesser angle to the horizontal.

Firing a Hand-Fired Down-Draft Furnace

METHOD REPORTED BY THE BUREAU OF MINES FOR DEVELOPING HIGH BOILER RATINGS FROM DOWN-DRAFT FURNACES. BY J. F. BARKLEY*

SMOKE regulations of the district of Columbia are extremely rigid and are well enforced. In several Government plants where hand firing of coal is still necessary, conditions have been satisfactorily met by installing the down-draft type of furnace. As at all hand-fired plants, considerable difference in operating details and methods is found. The firemen are paid day laborer's wages and are often inexperienced. The instructions of the furnace makers frequently do not appeal to the firemen and are not closely followed. This is due partly to the necessity of running the boilers continuously at much higher ratings than were intended by the manufacturer. Tests were made on a Hawley furnace of this type to improve the methods of firing, particularly at the higher ratings.

TABLE I. RESULTS OF THE COMPARATIVE TESTS

Test No.	1 & 2	3 & 4
Duration, hr.	46.86	45.93
Type of boiler	Down-draft locomotive return-tubular	
Per cent air space in lower grate	30	45
Upper or water grate surface, sq. ft.	34.5	34.5
Lower grate surface, sq. ft.	35.9	35.9
Boiler heating surface, sq. ft.	1549	1549
Combustion space volume (approx.), cu. ft.	116	116
Steam pressure by gage, lb./sq. in.	49.8	47.7
Force of draft, combustion chamber, in. water	0.249	0.269
Dry coal per hour, lb.	564	555
Boiler horsepower developed	171	180
Percentage of rated capacity developed	110	116
Units of evaporation per lb. of dry coal, lb.	10.47	11.17
Analysis of dry gases by volume:		
a. Carbon dioxide (CO_2), per cent	11.35	12.18
b. Oxygen (O_2), per cent	7.63	6.81
c. Carbon monoxide (CO), per cent	0.31	0.35
d. Nitrogen (N_2) by dif., per cent	80.71	80.66
Proximate analysis of coal as fired:		
a. Moisture, per cent	2.0	2.0
b. Volatile matter, per cent	16.9	16.9
c. Fixed carbon, per cent	73.7	73.7
d. Ash, per cent	7.4	7.4
B.t.u. per lb. of dry coal	14,400	14,400
Analysis of dry ash and refuse:		
a. Combustible, per cent	37.4	16.4
Efficiency of boiler and furnace, per cent	70.6	75.3
Loss due to combustible in ash and refuse, per cent	4.8	1.5

Instructions given by the makers of the furnace cover but one method of firing. Green coal is to be fired upon the top grate to a thickness of about 4 to 6 in., making a fuel-bed thickness on the top grate after firing of about 8 or 9 in. at the front to about 13 or 14 in. at the rear. A layer of fuel of 3 in. is recommended for the bottom grate, the ash-pit doors to be closed but the small air dampers mounted upon them to be open. The middle doors leading to the space between the two grates are to be kept closed, except when leveling or cleaning the bottom grate. Stress is laid on the inadvisability of breaking straight up through the top fire with the poker, thus tending to throw the ash up into the fuel bed. A method of hooking the fire by shoving a hook through the top door and parallel along the water grates underneath the layer of coal is recommended, thus knocking the ash and some coke down onto the lower grate. This method did not produce satisfactory results at higher ratings with the fuel used.

TABLE II. ANALYSIS OF FLUE GASES DURING THE FIRING PERIOD

CO_2 —Per	O_2 Cent—	CO	Remarks
15.3	2.6	2.2	Middle doors and their air dampers closed. Good lumpy coal, with some fines.
15.6	3.7	0.4	One middle door opened, air dampers open. Same coal.
13.5	3.0	3.1	Middle doors closed; air dampers closed. Finer mixed coal.
12.5	4.8	2.4	Middle doors closed; air dampers closed.
13.2	4.9	1.5	Middle doors closed; air dampers open.
12.7	5.7	0.6	One middle door opened; air dampers open.
11.5	6.6	0.7	One middle door opened; air dampers open.
9.3	8.9	0.2	One middle door opened; air dampers open.

Firemen who are used to a single grate are frequently confused when the double grates of a down-draft furnace are used. Air may reach the combustion space of the furnace by three different paths instead of one. It may go through the top firing doors and down through the top fuel bed; it may go through the middle doors directly to the combustion space; or it may go through the ash-pit doors and up through the bed of coke and ash. For a given position of the doors, if the top fire is proportionately too thick, the bottom fire burns out too rapidly. Holes will appear on the lower grate through which the larger part of the air will go, thus greatly reducing the flow of air through the top fuel bed. If the bottom fire is proportionately too thick, a greater proportion of the air passes through the top fire. This causes the top fire to burn out too rapidly. The volatile matter of the coal is meant to be distilled on the top grate, where also a part of the coke is burned.

On the bottom grate, coke only is burned. The combustible gases are to be burned in the combustion space, a part of which lies between the two grates. What proportion of the total coke will be burned on each grate depends upon the character of the coal, the firing methods used and the load on the boiler.

At one plant there were installed portable or locomotive type tubular boilers of 155 hp. each. These boilers were equipped with lower shaking grates, some having the air openings amounting to about 45 per cent of the total grate area, and some having the openings approximately 30 per cent. In the first grate the air spaces were ½ in.

*Fuel Engineer, Department of the Interior, Bureau of Mines.

in width and 5 in. long. They were evenly separated by a bar of about the same width, giving a uniform and well divided air distribution. For the other grate, the air spaces, while more irregular in shape, were of about the same size but separated by a bar about 1 in. wide. Comparative tests of these two types of grate were made to determine the effect of this difference upon the boiler efficiency as a whole, as shown in Table I.

The grate having closely spaced air openings aggregating 45 per cent of the area, showed a boiler and grate efficiency of 75.3 per cent against 70.6 per cent for the other grate. The difference is due almost entirely to the carbon loss in the refuse, it being 1.5 per cent and 4.8 per cent respectively. The air is better distributed through the 45 per cent grate, reaching into the coke more uniformly, particularly at the bottom of the coke bed. The size of the ash from the 45 per cent grate was much finer.

Efficiencies were good but higher boiler ratings were desired. It was found that for certain periods of the tests, excessive quantities of carbon monoxide were produced. With these boilers, a carbon monoxide content of 0.20 per cent in the flue gases causes about 1 per cent loss of the fuel. At times, this content rose to 2.5 per cent or more, showing a loss of some 10 per cent to 12 per cent of the fuel. These furnaces have a relatively small combustion space, the tube sheet being back from the furnace only about 36 in. Unless the fire was well handled, poor combustion resulted.

TABLE III. ANALYSIS OF FLUE GASES AFTER FIRING PERIOD

CO_2	O_2	CO	Remarks
—Per Cent—			
14.9	2.9	2.1	Middle doors closed, air dampers closed. Good lumpy coal, with some fines.
15.6	4.3	0.0	Eight minutes later; same setting.
14.9	2.7	1.4	Middle doors closed, air dampers closed. Good lumpy coal, with some fines.
16.4	3.4	0.0	Eight minutes later; same setting.
14.2	4.5	0.1	Middle doors closed, air dampers open.
11.1	6.8	0.5	Middle doors closed, air dampers closed. Finer mixed coal.
11.4	7.1	0.0	Middle doors closed, air dampers open.

Study was therefore made of the combustion during the different periods of the firing cycle at high ratings. The New River coal available for the most part was similar to that given in the previous tables, except that it was nearly all fines and contained few lumps. There was also mixed with it some slack coal from Pennsylvania, of a little higher volatile and ash. The boiler was equipped with a lower grate, having the 45 per cent air spaces. The flue-gas samples, of Table II, were taken while coal was being fired on the top grate. The ash-pit doors were closed, with their air dampers open.

It will be noted that an excessive amount of carbon monoxide was produced when the middle doors and the air damper upon them were closed. Opening the air dampers gave somewhat better combustion but the best results were obtained when one middle door was opened. At the higher ratings considerable smoke was made at the time of firing with the middle doors closed. Opening the middle door reduced this smoke, so that it was permissible under the city smoke ordinance. It was also found that firing too rapidly or breaking up the fire too impetuously increased the carbon monoxide content of the flue gases.

Samples were taken during a period of about 3 min. after the firing was finished and the middle door closed. After some of the samples, a wait of about 8 to 10 min. was made and another 3 min. sample taken, as shown by Table III.

These results show the desirability of opening the air dampers in the middle doors for about 2 to 3 min. after firing, to prevent the formation of carbon monoxide. They must then be shut in order to cut off the air which is no longer needed through the middle doors.

Study was made covering the proper thickness for the top and bottom fires. This will vary considerably, depending upon the coal and the load on the boiler. A thickness of the top fuel bed of, say, 9 in., with draft, which varied from 0.30 to as high as 0.47 in. of water in the furnace proper, caused carbon monoxide to appear. This was also true when the bottom fire was carried much over 4 in. thick. The bottom fire has an important bearing on efficiency not always realized by the fireman. Black spots show a flow of cold air and must be covered. The fire should be well leveled.

TABLE IV. FUEL GAS ANALYSIS USING MIXED FUEL

CO_2	O_2	CO	Boiler Rating	Efficiency	Remarks
11.90	6.99	0.36	152	74.5	No attention to middle doors. Air dampers open in ash-pit doors.
11.50	7.80	0.30	157	73.0	No attention to middle doors. Bottom doors wide open.
11.53	7.73	0.00	148	76.1	Every attention given. Air dampers only, open in bottom doors.
13.20	6.10	0.06	152	76.5	Every attention given. Bottom doors wide open.

The top fire should be 6 in. thick after firing; let it burn down to about 4 in. Keep the bottom fire 3 in. thick. Before starting to fire, open the air dampers in the middle doors and open one middle door. Fire not too quickly over the entire top bed, covering the red coke. Level over the bottom fire. Shut the middle door. After about 1 min., depending upon how long a time the leveling of the bottom fire required, shut the air dampers in middle doors. When the top fire begins to cake over and the flame shorten, open the air dampers in the middle doors and break the fire straight up through with the poker, loosening up the entire fuel bed well. Then level. At this stage, the boiler rating rises very rapidly. Shake the lower grates at long intervals, as shown by the condition of lower fuel bed. No clinkers were found on either grate. In another plant with the same furnace and coal but a different scheme of firing, the clinkers accumulated to such an extent in the top fire as well as the bottom, that the entire fire had to be cleaned every 8 hr., getting large masses of clinker. This was due largely to carrying a thick fire that gave a much lower boiler rating.

Table IV shows some of the results obtained at the higher ratings with mixed slack coal.

Coal Hoisted by Use of Power Chain Block

EQUIPMENT IS frequently put into power plants which in its operation imposes too great a physical effort upon the part of the operators. It is to be expected that a few conditions of this kind will get by the designer. The greatest fault lies in not remedying these conditions as soon as they become apparent.

One excellent example of remedying a condition of this kind is the installation of an electrically operated chain

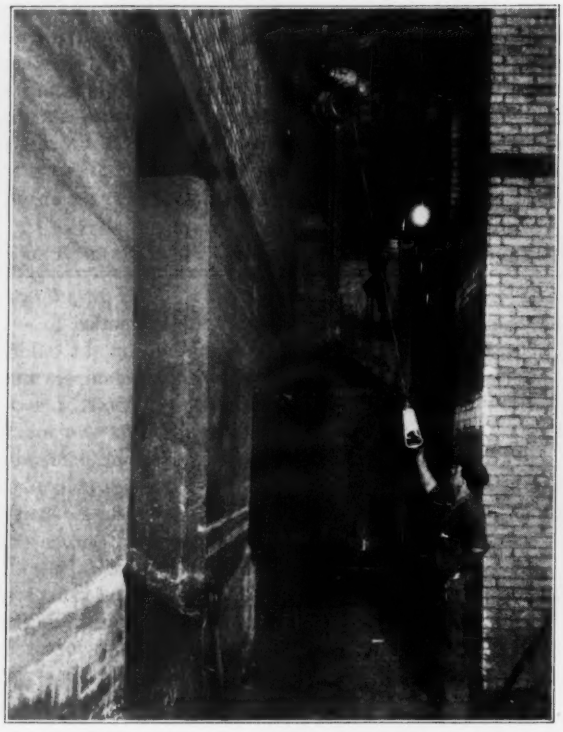


FIG. 1. ELECTRICALLY OPERATED CHAIN BLOCK NOW RAISES THE LOAD

block in the boiler room of the Hotel Pantlind, Grand Rapids, Mich. This block did the work in one minute, without any physical effort upon the part of the operator, which had formerly been a gruelling 7-min. job by the operator. Coal is handled in rather a unique manner in this plant in that the buckets in which the coal is conveyed to the stokers are set upon the standard stoker hopper. No extension having been built, these buckets then serve in the place of hopper extensions.

Coal is stored in two rooms, the floors of which are level with the top of a coal bucket when it is placed on the operating floor. With this arrangement it is comparatively easy for the operator to load the buckets by hand because he does not have to lift the coal and throw it at the same time. To transport each bucket from the storage room to its resting place on the stoker hopper, there had been provided a mono-rail and chain hoists.

After a bucket had been loaded with coal, its total weight then being about 2300 lb., it was up to the operator to spend the next 7 min. tugging away at the chain in order to raise the load to a height of about 7 ft. The load was then moved along the mono-rail, by means of a hand operated geared trolley to the boiler fronts where switches could be thrown to shunt the bucket to any one of the three boilers. The bucket having been spotted over a stoker hopper it was lowered in place, a gate opened in its bottom and the coal fed as required by the stoker.

This scheme worked out easily except every operator who tackled the job objected to the strenuous effort required on the initial lift of 7 ft. A number of operators had quit simply on account of it. To overcome the difficulty it was decided to buy a small electrically operated chain hoist. The load to be handled was 45,000 lb. of coal per 24 hr. This was distributed throughout the day as follows: 14 buckets from 8 a. m. to 4 p. m.; 12 buckets from 4 p. m. to midnight and 8 buckets from midnight to 8 a. m. This meant of course that the motor on the

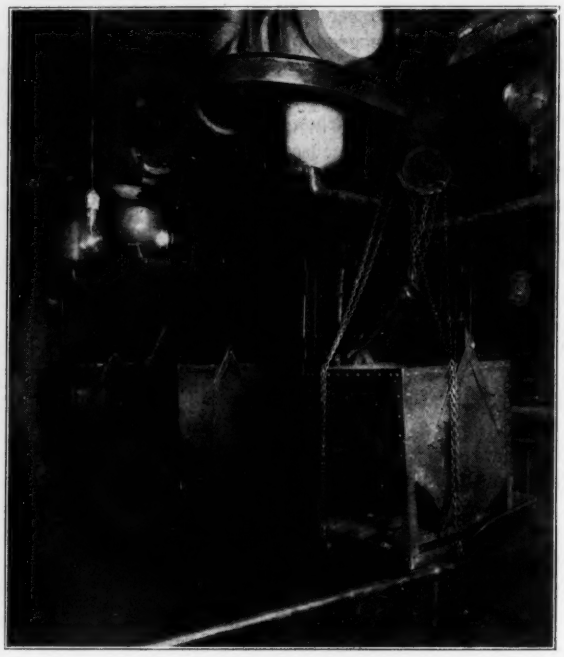


FIG. 2. COAL TRANSPORT BUCKETS ARE USED IN THE PLACE OF STOKER HOPPER EXTENSIONS

hoist would be used intermittently, therefore some money could be saved by purchasing a 2000-lb. block rather than one of 3000 lb. capacity.

It was not necessary, in installing the new block, to discard any of the old equipment. The block was permanently slung from a short beam which was already in place. The control was dropped so that it is within easy reach of the operator. As each bucket is loaded, the electric chain hoist is hooked onto the bail, the operator throws the switch and in less than a minute the bucket is hoisted a few inches over 7 ft. from the floor. The old hand operated block follows the load up and the electric block is then reversed so that the load is eased down onto the hand-operated chain block.

It has been of considerable interest to note the change in attitude which the operators have since this change was made. Men no longer quit because of the complaint that the work is too hard. The electrical device is so appreciated that each operator watches the other when using it in order to assure himself that the new electrically operated chain block will not be abused.

Systematic Methods for Oil Engine Plants

PRIME MOVERS COMMITTEE OF THE N. E. L. A. STRESSES VALUE OF DEFINITE MAINTENANCE PROCEDURE AND RECORD SYSTEMS

IN THIS year's report of the Oil and Gas Engine Section of the Prime Movers Committee of the National Electric Light Association, considerable attention is given to a discussion of the cost of operating oil engines; the problems involved in keeping them in repair and a suggested accounting system for keeping the operating records of oil engine stations on a business-like basis.

Some of the cost figures which have been cited in the report were taken from a compilation which was made by the Diesel Engine Users' Association of Great Britain. This report shows detailed operating costs for six Diesel engine stations in Great Britain with capacities ranging from 100 to 855 kw. covering the years 1917 to 1921 inclusive and also for two plants in India; one for a five-year period and the other for a three-year period.

Table I shows the operating costs for three of these plants for the year 1923. Plant "A" located in India is

TABLE I. ESTIMATED OPERATING COSTS FOR BRITISH AND INDIAN DIESEL ENGINE POWER PLANTS, 1923

Unit Costs	British	Indian A	Indian B
Fuel Oil, Cents per Lb.	1.00	1.47	0.59
Lubricating Oil, Cents per Gal.	60.8	91.00	91.00
Wages, Average Weekly	$163.40	....	....
Operating Costs Mills per Kw. Hr.			
Running Costs:			
Fuel Oil	6.56 Mills	10.10 Mills	4.12 Mills
Lubricating Oil	0.86	2.22	2.22
Water	0.04	0.06	0.08
Stores	0.20	0.08	0.16
Wages	5.16	3.68	2.28
Maintenance Costs	2.96	2.70	2.70
Gross Cost	15.78	18.84	11.56

about 1000 mi. inland, while Plant "B" is on the seacoast. This explains the difference in the fuel cost. Even though these figures are for plants operating under conditions differing widely from those in this country, they show close agreement with corresponding costs for American plants according to the committee.

Another report on costs of operation which is presented by the committee is that made by Charles Legrand, consulting engineer for the Phelps Dodge Corporation. Mr. Legrand estimates the average maintenance cost for large two-cycle engines at $0.002. per kw.-hr. Installations which are mentioned in his report are located in the Arizona mining territory, equipped with two-cycle Nordberg-Carels engines varying from 1250 to 2000 hp.

Table II shows the operating costs for three of these plants. These costs, however, include no taxes or general overhead cost, but in all supplies and labor the overhead costs of the supply and mechanical departments are added.

Mr. Legrand calls attention to the fact that the labor cost for these three plants is somewhat low due to the fact that the costs do not run over a sufficiently long period. In his opinion, under present cost of operation and take over a sufficiently long interval to cover major

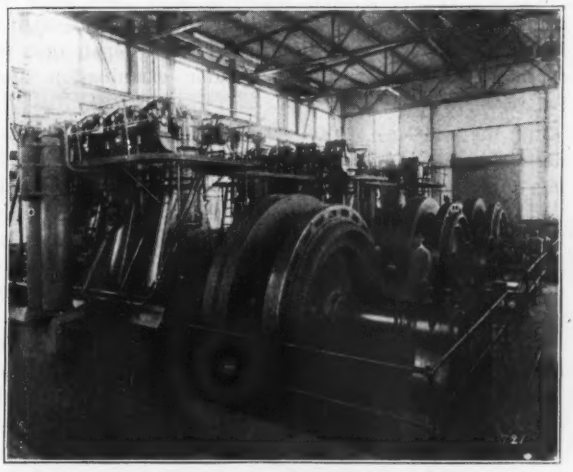


FIG. 1. COMPLETE RECORD SYSTEMS ARE ESSENTIAL IN DETERMINING THE OPERATING RESULTS OF OIL ENGINE EQUIPMENT

The plant shown is one operated by the Texas Power & Light Co. and is equipped with three McIntosh & Seymour engines.

periodical repairs, this item would be increased to $0.002 per kw.-hr.

In commenting on the fuel oil, he states that California 14 deg. B. fuel oil or Mexican 14 deg. B. oil is utilized for running oil. The Mexican oil contains as much as 4½ per cent sulphur and averages about 3¾ per cent. This increases the difficulties of cylinder lubrication and the maintenance cost of the cylinders and piston rings. It also makes it necessary to carry the exhaust gases away from steel buildings and cooling towers as sulphuric acid is found when the temperature of the gases is lowered. It is also troublesome to handle when cold.

It is also stated that the load factor on the engines and on the plant and the number of times the engines are stopped and started has a marked effect on the fuel consumption, as the consumption varies from 5 to 20 per cent

TABLE II. COST OF OPERATION FOR THREE PLANTS OF THE PHELPS-DODGE CORPORATION

	Globe	Morenci	Tyrone
Operating Labor	$0.00149	$0.00158	$0.00819
Lubrication	0.00018	0.00024	0.00047
Repairs	0.00086	0.0013	0.00115
Fuel Oil	0.00603	0.00524	0.00935
Miscel. Expense	0.00022	0.00041	0.00052
Total per Kw. Hr. Distributed	$0.00878	$0.00877	$0.01968
Cost of Fuel, per Bbl.	$2.52	$2.18	$2.67

more than shown on test runs for the load corresponding to the average load on the engine. For example: Referring to Table II, the plant at Globe during the first five months of this year averaged 587 kw. per engine with a peak load of 900 kw. per engine and the fuel consumption was 0.765 lb. per kw.-hr. The test curve for a load of 587 kw. shows a fuel consumption of 0.695 lb.

Maintenance of oil engines is discussed at some length by the committee and the point is made that the manufacturers are endeavoring to effect closer relations with companies operating these engines. They have come to realize that it costs less throughout the life of an engine to maintain it by systematic inspection and repair than to operate indefinitely without regular examination and renewal of the worn parts.

In the past, one of the serious items of engine maintenance has been that due to crank shaft breakage. According to the committee it is now well established that crank shaft breakage is, in practically every case, the result of faulty bearing alinement which can be overcome by careful bedding of the crank shaft when bearing linings are replaced and by frequent inspection and rebedding as found necessary.

One company has outlined its method of handling this type of work. The method is used in the maintenance of 24 Diesel engines and the company has not had a crank shaft failure in any of these engines for the past five years. This proves quite conclusively that crank shaft breakage can be eliminated by careful maintenance and that the method described accomplishes the desired result. The method is as follows:

To fit a new set of bearing shells, the pistons and connecting rods are removed and the flywheel dismantled if it is on the crank shaft. The lower half of each shell is inserted in its place and those found to be high are scraped until all journals have good bearings. By means of a cast iron bridge, spanning across the journal on the finished surfaces of the pedestals, the distance to the top of each journal is measured with a feeler or inside micrometer. This information is carefully recorded for comparison with future measurements. At each plant, a bridge is carefully preserved for use in making these tests. After this work is completed, the upper halves of the shells are fitted and set for a clearance of 0.0006 in. per inch of shaft diameter.

Main bearings cap adjustment: Remove all doors; raise main bearing caps one at a time and note lubrication of main bearings. Examine babbit and see if it has ever wiped. Clean caps and oil holes and adjust caps for proper journal clearance, taking load readings as required. When No. 4 cap is removed note the condition of the crank shaft gear and see that same is tight in place. Note the thrust play in crank shaft. See that all main bearings are secure and that all locking devices are in place on the wedge adjusting screws. Remove outboard bearing caps and examine bearings in a similar manner. Note conditions of oil in pedestals and see that oil chains are in place.

At time of annual overhauling of engine, the crank shaft is lifted and supported on a crescent shaped bronze block, about ¾ in. thick at center, at each end bearing, and tested with dial test indicator at each of the other journals. If found necessary, true up the journals. Of course the bearing shells are examined and replaced as necessary. After this the shaft is rebedded, in the same manner as for new shells, if found necessary.

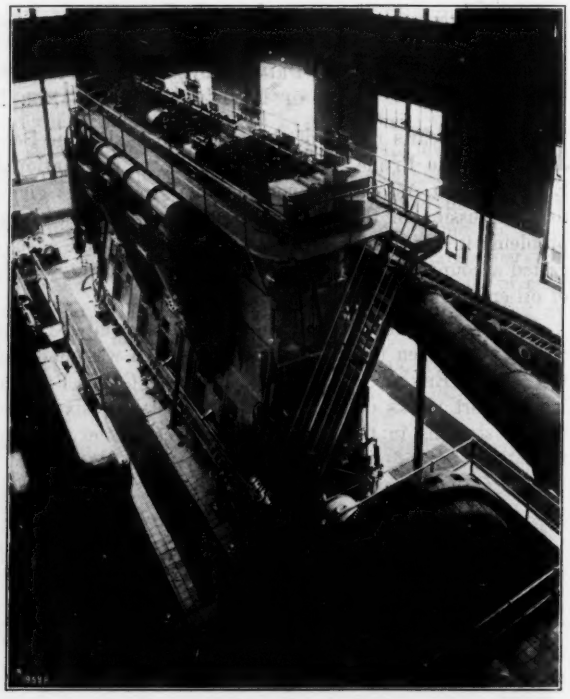


FIG. 2. SYSTEMATIC INSPECTION AND MAINTENANCE IS ESSENTIAL IF DIESEL ENGINE REPAIR COSTS ARE TO BE KEPT AT A MINIMUM

The view shows one of the new Bethlehem engines. This particular unit is rated at 3500 I. hp.

It has been found that normally the shaft, in the course of one year's operation, will wear the middle bearings from 0.010 in. to 0.025 in. more than the end bearings. The latter figure is considered to be the maximum safe misalinement. When a bearing overheats and wipes babbit from the lower half of one bearing, a misalinement of this one bearing of 0.010 in. is considered dangerous.

Uniform Accounting Methods

After considering the general problems of maintenance, the committee raises the point that the wide differences in accounting system make it extremely difficult to compare the cost of operating oil engine plants. This is particularly true when it comes to a study of maintenance costs and the various items entering into operating expenses. With this thought in mind, the committee has therefore suggested general classifications for a uniform accounting system. Space does not permit a complete presentation of these classifications, although the main headings will furnish the key to the scheme.

Under general operating expenses the following main classifications of accounting are suggested: Superintendence; Fuel Labor; Engine Labor; Electrical Labor; Miscellaneous Labor; Engine Fuel; Water; Lubricants; Production Supplies; Station Expense.

Under maintenance the main classifications are as follows: Station Buildings; Fuel Storage Equipment and Accessories; Prime Movers; Air Injection System; Cooling Water System; Main Generators; Exciting Apparatus; Control and Protective Apparatus; Transformers and Converting Apparatus; Miscellaneous Power Plant Equipment.

Ice Control Methods at Shelburne Falls*

CONSTANT WORK IS REQUIRED TO KEEP THE CHANNELS OPEN AND THE UNITS RUNNING UP TO CAPACITY. BY JAMES H. KENNEDY**

ICE CONTROL on the Deerfield River in Massachusetts at the several plants of the New England Power Co. is a serious operating problem, one that requires active attention on the part of the whole operating staff. During the winter it is no child's play to keep the fore bay open and the station operating up to capacity. Various methods are used to break up ice formations; in some cases it is best to use manual effort, in others dynamite can be used to advantage.

At Number 4 pond the backbone of the ice is broken by the use of dynamite. A force of men start at the head of the pond at Clessons River Bridge, cutting holes through the ice about 25 ft. apart and blasting down river around the curve in the pond shown in Fig. 1. This is done to break the resistance of the ice and keep it from going in a straight line into the bank and piling up on the curve.

FIG. 1. BLASTING ICE ABOVE DAM NO. 4 AIDS IN KEEPING THE CHANNEL OPEN

It makes the turn and the ice is pushed to either side of the river or submerged in the pond where it is ground to small pieces and carried away with the flow.

An interesting feature in connection with Number 4 station is illustrated in Fig. 2 which shows booms and mats extending across the forebay from the tunnel outlet (over which the photographer stood) to either side of the intake structure. The use of booms and mats is confined entirely to the winter months.

During the first few years of plant operation Number 4 forebay was a part of the development that gave trouble. Due to its saucer shape and the wide range of elevation in the forebay, heavy ice would form during shut-down periods. This ice would become a whirling mass of floats in early spring. The wooden rack, placed on the outer side to prevent ice coming in against the steel rack, would be broken like a straw.

Men and teams were used and still there would be a loss in station capacity. It was decided to install the boom

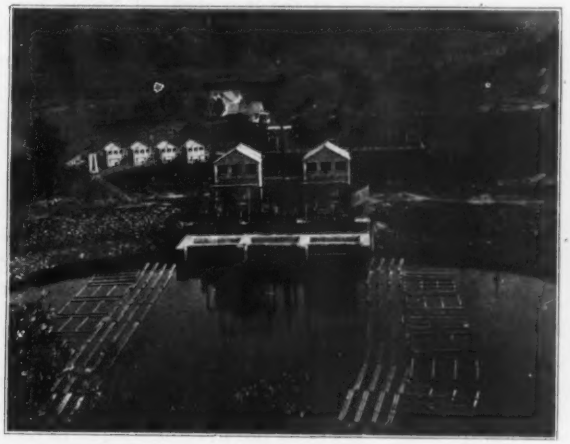


FIG. 2. LOG BOOMS AND MATS IN THE FOREBAY OF STATION NO. 4 ON THE DEERFIELD RIVER

and mats, the action of which, when frozen into the ice, is similar to that of reinforcement in concrete. The ice is held on either side in a solid mass as shown in Fig. 3 and thaws out in the spring without causing any trouble.

The booms are made up of seven sections of four 12 by 12-in. spruce timbers 14 ft. in length, spaced on 4-ft. centers. Each section is chained together to allow flexibility. An anchor chain is provided at each end and the boom is cross cabled in order to permit freedom of motion over a large range of elevation. On the bank side of the booms are six sections of mats made up of 2 by 6-in. stock 12 ft. long, which are fastened to the booms by cable loops.

For the past few years at Number 3 dam a section of pond ice 120-ft. wide and 300-ft. long extending up-stream to the bridge on the Shelburne Falls side, has been sawed out and sluiced over the dam. A path of least resistance is created and when the break-up comes, the ice and debris is passed over that section instead of choking

*Abstract of an article appearing in the May issue of "Contact," published by the New England Power Co.

**Superintendent of Stations Nos. 2, 3, and 4, of the New England Power Co.

TO KEEP THE CHANNELS OPEN AND THE FLASHBOARDS FREE FROM ICE REQUIRES CONSTANT WORK

Fig. 3. To insure continuity of operation a clear channel must be maintained from the tunnel outlet at all times. Fig. 4. Clearing ice from the down-stream side of the flash boards at No. 4 dam is a hazardous undertaking. Fig. 5. If the flash boards are to be kept intact a trench must be kept open just ahead of them. A 2-ft. trench is therefore cut out every morning.

the channel leading to the intake of the canal. In this way it is possible to keep Number 3 station up to capacity.

During the winter months one of the outdoor sports is to keep the pins and gates free from ice in weather 10 below zero. Each morning the dam must be sluiced, that is, a trench 2-ft. wide between the boards and the ice on the pond is cut out as shown in Fig. 5. The pond ice, whether it is 6 or 24 in. in thickness, is constantly moving downstream due to the water elevation changing from 6 to 8 ft. several times a day, and consequently the trench is narrowed.

On the left in Fig. 5 is shown the boom trenched on either side and the braces extending to the bank. The boom must ride freely or the movement of the ice downstream will press the end of the boom against the concrete head works with pressure sufficient to prevent rise and fall with changes in water elevation. The boom is anchored with cable but if not given freedom of motion it would be broken by the weight of thousands of tons of ice.

At the first sign of rise in temperature a force of men is started cutting the ice on the downstream side of the boards. In severe weather ice accumulates from 3 to 5 ft. thick. It is beautiful to look at, with all kinds of fancy designs, and tapers down at an angle of about 45 deg. It is necessary to cut a horizontal niche, as would an Alpine climber, before locating to start work. This is done with pickaxes and needle bars. In case of high water this ice must be removed first or the boards cannot be taken off. This work is illustrated in Fig. 4.

The pins are also frozen in the thimbles which are cemented into the crest of the dam. If the temperature is high enough during a thaw the heat taken up by the metal pins will be sufficient to loosen them, otherwise we fire up a boiler and thaw them out with steam.

In connection with all work relative to maintenance of the highest possible station capacity, it is vital that no time be wasted, for the Deerfield, like time and tide, "waits for no man."

Central Station vs. Industrial Power Plants

MANY AND VARIED ARE THE FACTORS TO BE CONSIDERED IN MAKING A CHANGE FROM ONE FORM OF SERVICE TO THE OTHER. BY W. J. RISLEY, JR.*

TEN YEARS ago—yes, even five years ago—the industrial power plant was as much a necessity as was daylight. Few architects in designing a new mill or factory stopped to make an analysis of the power, process steam and heating requirements of the projected plant to determine whether the purchase of central station power would be economical. During the heating season the plant had to be heated and it was usually cheaper to operate the private plant for power as well as heat the year around even though this meant expensive power in the summer.

Now, the work of the architect or consulting engineer in designing a new industrial plant nearly always includes a careful analysis of the power, heat and process steam demands anticipated, both as to nature and amount. This analysis often shows that the greatest ultimate economy is to be obtained by relying entirely on central station service for power requirements and operating a small number of boilers for heating and process demands.

This change is not limited to new construction. Scores of plants which have been in operation for 5, 10 and even 15 yr., some of which are in deplorable condition and some of which have been maintained in top-notch condition and retain their original economy, are changing over to central power service. Even paper mills, which have enormous heat demands in comparison with most industrial plants and which a few years ago were considered to be in a better position to sell power to the public utilities rather than to purchase power, are adopting central service.

Why all this radical change within a few years? Why this about-face in a period of time one-fourth as great as a transformation of such extent usually requires? There must be some fundamentally good reasons for a doubling of public utility power output in the last 5 yr., and for an ever-increasing rate of growth from year to year.

Advances in the art of central station power generation have led to rate reductions. Public utility power sales departments have converted these reductions into an increased volume of business. More volume has justified further improvements and refinements in station economy and these in turn have caused further rate reductions. This circle, which could hardly be termed a "vicious circle," has been responsible for the extremely favorable position in which the public utilities now stand.

Few of these advances in the art of power generation, however, have been found to be adaptable to the industrial power plant to give it a like reduction in the costs of producing power. Central station operating pressures and superheats have doubled, and more, in the last 5 yr., but how much general increase has there been in these conditions for industrial power plants? Extremely high boiler ratings in normal operation, air-preheaters, steam reheating cycles, stage bleeding for feed-water heating, and now the mercury boiler—all these are being developed for central station service, but to what extent have they been used or are they likely to be used in small power plants? These improvements depend on a high average load factor and few private plants can meet the requirements to obtain these economies.

On the other hand, the Diesel engine is rapidly being developed to the point where it is being given consideration for small plants, and particularly for small isolated public utility stations. This is an improvement in economy which will scarcely enter into the central station field as far as large stations, 50,000 kw. or over, are concerned, but which will be applicable in small plants and in industrial work; however, even the Diesel, with its extremely high fuel economy, can justify itself only in certain cases because of the heavy fixed charges involved.

It will be well for every industrial power plant operating engineer to take stock of his own situation and to determine whether or not central station power holds anything for his plant. In this connection there are several points which he must keep in mind since every plant is a case in itself and no definite rules can be given.

In the first place, the relation between power and heat demands is of the utmost importance. As long as no buildings are added to the plant or additional stories built,

*Engineer, Curtis Publishing Co.

the heating steam requirements are going to be subject to little change from year to year. It is more usual to expect a growth in the volume of business done by the company, which would ordinarily mean an increasing power load.

Assume a plant in which more steam is required for heating than can be furnished by the exhaust from the engines. An increasing power demand is then supplied, during probably 6 or 7 mo. at almost no additional expense, as long as there is still a margin of generating capacity available. Assume, on the other hand, a plant in which the exhaust from the generating units furnishes 30 per cent more steam than is needed to heat the buildings. Then this extra steam must be wasted, unless there happens to be a process use for it, and the power which furnished this exhaust as a byproduct would show a steam cost alone of over 2 cents a kw.-hr.

Any increase in power demands would likewise be expensive and it might pay well to consider the advisability of an outside source of power. A case in point is that of an establishment which had the matter of central station service carefully investigated less than 3 yr. ago. At that time heating requirements exceeded the power demand and it was found that the private plant, which was well maintained and showed an excellent economy, could be operated more economically without purchased power.

Since that time the power requirements have increased enormously until they considerably exceed the heating demands and, though the power plant is still operated at the same economy, it is found that a combination operation will show a considerable saving. A saving could even be effected if all the power were purchased.

Importance of High Load Factor

Another consideration, and one which is frequently slighted, is the importance of the maximum demand and of the average load factor. With a private plant, a heavy load late in the afternoon, or at any time for that matter, might mean nothing more than a temporary overload on the generating units and the unit cost of this extra current would probably be no more than that of the regular load.

Suppose, however, that this power were being purchased from the public utility. The charge for electricity is made up of two parts: a demand charge, which is usually based on the highest point below which the plant's load does not drop for 30 min. (called "the 30-min. demand"); and a current charge, which is based on the quantity of current consumed. Now if the load is a steady one, day in and day out, with no abnormal peaks, then the load factor is high and the demand charge may be only 20 to 25 per cent of the total power bill. Under these conditions the total cost per kw.-hr. will be quite low, and central station service can be considered.

Suppose, on the other hand, that there is a period from about 4 until 5 o'clock every afternoon, or even only on one or two afternoons a month, when the load is abnormally high, say 50 per cent above the normal load. Under these conditions the demand charge will be high, since it is based on the highest 30-min. demand in the month. The demand charge might even amount to 50 per cent of the total power bill and this would possibly make the total power cost per kw.-hr. (even though the actual amount of current consumed were no greater than in the preceding case) so high that this item alone might justify the continued operation of the private power plant.

Possibility of Combined Service

It occasionally happens that the industrial power plant is large enough and is sufficiently well operated that the public utility will make an arrangement whereby all power will be purchased during the non-heating season and the central station service conversion units, if such must be installed to change high-tension alternating current over into lower voltage or direct-current power, will be operated in parallel with the plant's own generating equipment. This arrangement would be feasible when the total power requirements of the plant were considerably in excess of the heating steam demands, in which case the plant's steam units would generate only enough power to supply exhaust steam for heating and the balance of the power would be purchased.

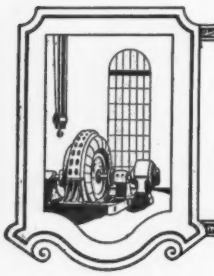
Such an arrangement, although not a common one, would work to the advantage of both parties. It would relieve the public utility of a small portion of its load during the winter, when the power demands are always heaviest anyway, and it would enable the consumer to generate a portion of his own power at a comparatively low cost.

Wherever such an arrangement is feasible it is best to retain as much as possible of the plant's own generating capacity if central power service is adopted. This is particularly advisable if the central station's continuity of service record is anything but the best, since the retention of the steam units will give the plant something to fall back on if the central power should fail. Later on, when the reliability of the service has been demonstrated to the satisfaction of the plant officials, the disposal of the steam units can be considered.

Another point must be kept in mind when a change to purchased power is considered. How much will it be practicable to reduce the operating force? When the public utility power salesman submits his estimate, he is naturally prone to be over-optimistic with regard to the saving in labor costs which his proposition will bring. No industrial power plant, regardless of the nature of the equipment, can be operated by absent treatment, nor can an entire operating force be disbanded in May of each year and assembled again in October when the heating season begins. Satisfactory results can never be obtained under such conditions. It is better to be conservative in reducing the operating force at first and make further reductions later if such a step is found advisable.

One more thing must be carefully considered. How much capital expenditure is required for making the change? Will the resultant savings be certain to show a materially higher return on the investment than can be earned in the business itself? The industrial plant is not in business to make power; it manufactures machinery or textiles or paper or some other product. It would be foolish to tie up a large amount of money in power equipment which would return 10 per cent, when the same money invested in the business itself would show 12 to 15 per cent. This will be the final criterion and it is one which the operating engineer should always keep in mind.

Performance characteristics of a centrifugal pump depends on the design of the pump runner. For a change of speed the capacity will change in direct proportion to the speed change, the head will change in direct proportion to the square of the speeds and the horse power in direct proportion to the cube of the speed.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Unusual Phases of Power House Lighting

ILLUMINATION OF THE CONTROL AND DISTRIBUTION ROOM. CONSIDERATION OF REQUIREMENTS AND METHODS OF LIGHTING. BY A. F. LOEWE*

IN EARLIER DAYS of power production, problems of adequate and proper illumination of various areas in electric stations were limited in number and of simple type, due to the fact that the various component units were ordinarily placed close together and were small in size.

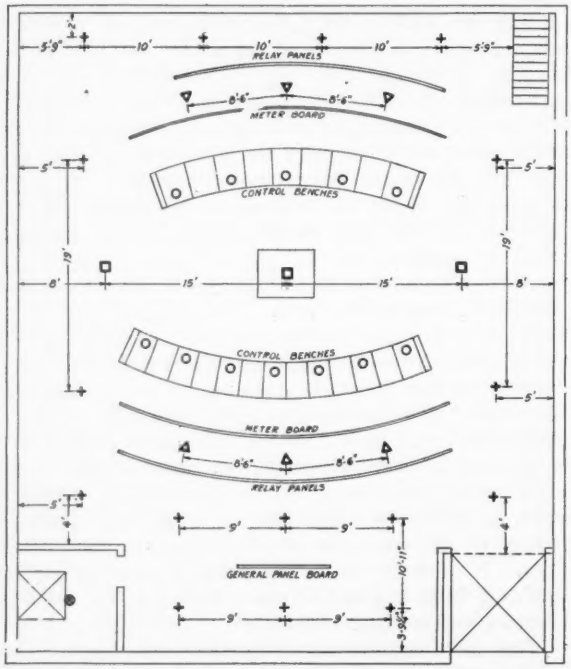


FIG. 1. PLAN OF CONTROL ROOM SHOWING TYPES AND LOCATION OF EQUIPMENT

The present day power station, however, is a mammoth structure in which the various units for production, control and distribution of power are housed in structures widely separated varying in size from the enormous turbine rooms with their high ceilings to the long, low-ceiled bus bar chambers. Conditions vary from the showy control room where we find the atmosphere of a well ordered office to the outside substation exposed to all the inclemency of varied weather conditions.

In all parts of the power stations, regardless of time or weather, the attendant must be in a position to attend to his duties with a surety and celerity possible only with good lighting.

*Lighting Service Dept., Edison Lamp Works, Harrison, N. J.

There are many places which present no especial difficulties but may be treated in the same ways as are industrial plants requiring general consideration of intensity, distribution and quality of light. The areas to be discussed in this issue are those in which extraordinary conditions are encountered, namely, the control room, load dispatcher's room and outdoor substations.

Visualizing the up-to-date control room, we see a rectangular room, in the center of which stands the operator's desk and phone board, flanked on either side by continuous feeder and generator control benches in back of which are the rows of meter and relay boards or the more modern cubicle units which combine both, the benches and boards laid out either in straight lines or on the axis of non-concentric circles. The meter and relay boards present vertical surfaces almost entirely covered by glass covered, white dialed meters mounted on black slate panels. The sloping tops of the control bench present a similar black surface studded with knife switches, push buttons and their indicating name plates and luminous bulls' eyes. Where one operator may be termed a potential guardian of the safety of life and property of many communities, it is readily seen that he should be attended with every aid for the efficient carrying on of his duties. One of his most important adjuvants is proper illumination.

ILLUMINATION REQUIREMENTS OF CONTROL ROOM

In any occupation requiring visual acuity it is self evident that in order to carry on efficiently, sufficient intensity is required to reflect images of various objects with clarity. The system of illumination to gain the desired results will vary with the special requirements of the interior and occupation with which we have to deal. The exact location of the units to be used will depend upon the character of light sources, type of luminaire, ability to diffuse and distribute the light, avoidance of glare and strong contrast, structural conditions, decorative effects desired, accessibility of luminaires and economy of operation.

Efficient operation of control rooms demands that at all times the operator is enabled to read from his station the approximate position of each and every indicator on his boards.

The fact that his station is not on the center of the axis on which the boards are installed precludes the possibility of accurate meter reading, due to parallax; however, through continued reading, from his station and again in front of the boards, the experienced operator is

enabled to tell at a glance from his station whether or not the customary loads are indicated. In times of emergency, however, when quick and accurate thoughts and actions are a necessity, the operator should not have to rely upon his own judgment as to the reading of the various meters but should have every facility for accurate reading.

Since so many tests have been made both in theoretical and practical applications proving the benefits of high intensities, it has become almost axiomatic that increasing intensities bring increasing clarity and speed of vision. It follows, then, that the higher the intensities available for meter reading the more efficient will be the operation of the control.

In that surfaces on which critical vision is necessary are in a vertical plane it follows from an economic standpoint that the maximum directional component of light should be suitable for illumination of that same plane.

This factor then introduces certain limiting conditions as to position of light sources and types of luminaires and reflectors. To obtain the desired result with respect to the economic directional component of light, we may use several means. For example, local lights either singly with angle type reflectors, or continuous trough lights, or light projected at an angle from a distance with suitable equipment. Midway between these two systems may be considered the use of enclosing globes of the light directing variety from which good illumination of vertical surfaces may be obtained.

With any of these various means specular reflection or images of the light sources may result on the meter glasses. Where conditions allow but one position from which the meters may be read, these types of installations may be so planned that the undesirable reflections will be in such a direction as not to enter the operator's eye. This condition, however, is rarely met with in the modern control room.

Aside from the glare caused by reflection from the meter surfaces there will be, in some of these installations, considerable direct glare caused by unshielded lights in reflectors and projectors.

With the use of diffusing globes the factor of undesirable contrast between the usual black surfaced meter boards and the bright globe surface may be found detrimental for some installations with comparatively low ceiling height.

Eye fatigue and visual discomfort due to contrast may be obtained not only from primary light sources of comparatively small areas of high surface brightness but as well from large areas of relatively low surface brightness, if these areas remain in the field of vision for any considerable length of time.

A particular case of this nature was recently called to the writer's attention. The control room of an exceedingly large power station had a system of totally indirect lighting installed from which was obtained a very uniformly illuminated ceiling.

The broad expanse of bright ceiling behind the meter panels was so trying on the eyes of the operator that it was almost impossible to take his necessary readings. To overcome this it was found necessary to turn out all lights behind the panels.

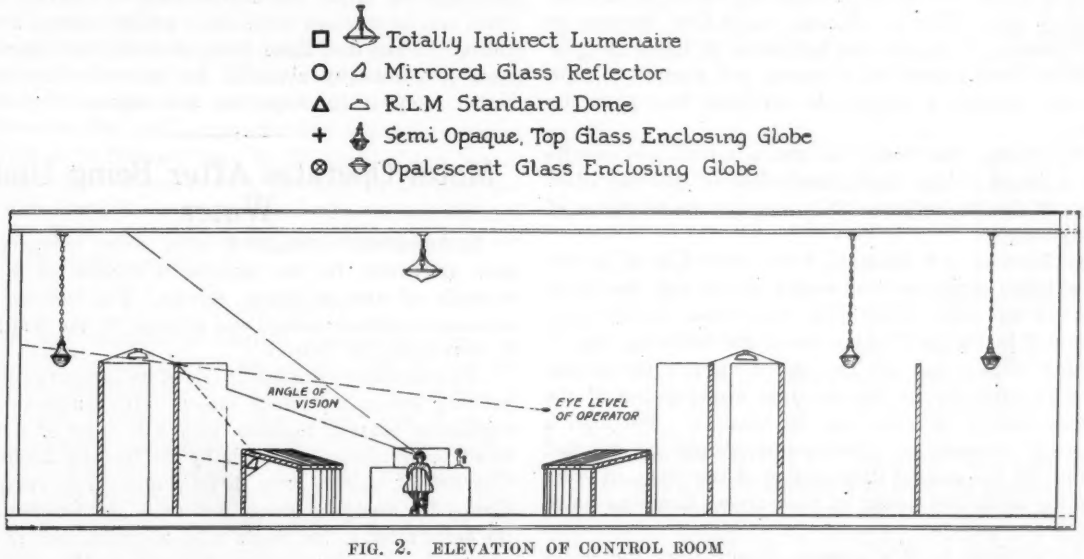


FIG. 2. ELEVATION OF CONTROL ROOM

In the foregoing paragraphs it is to be noted that all installations either had light sources in the field of vision or brought about conditions contrary to those under which the human eye has been developed. There is, however, a means of adapting artificial light, which with the increasing knowledge of the benefits of good illumination is becoming more and more popular—that is externally illuminated ceiling light.

Use of Skylights

There are certain characteristics of this type of illumination which must be borne in mind, not only in their designing and initial installation but throughout the useful life of the building. Some of the former are the relative values of the light as a decorative element in the room and its utilitarian element as a source of illumination. The ratio of supporting frame work area to that of the glass must be such that individual panes of glass do not appear as single sources of light. The type of glass must be such that the rays of light are broken up to some extent without losing altogether their initial directions, and the absorption of light rays is not excessive.

In the immediate surroundings of a power station it is only natural to expect that a considerable amount of dust will be borne in the air.

Smoke precipitators, coal and ash handling machinery are being brought to such a state of perfection that this condition is being bettered as time goes on; however, the possibilities of dust and dirt accumulations during a short space of time, must still be borne in mind in the planning of any type of lighting system.

The average skylight is built for a twofold purpose: namely, for illumination and ventilation. If, however, a system of external skylight illumination is decided upon, using the pent house to install lamps and reflectors in, the ventilation characteristics of the skylight must be done away with. It is a fact that when the velocity of dust laden currents of air is suddenly changed, the dust is precipitated to a great degree. This readily explains the rapid accumulations of dust in and under pent house skylights. The detrimental effects of a light film of dust on surfaces through which light is projected, have been found in actual practice to decrease efficiencies 50 per cent in many cases. This is sufficient reason that the area in which lamps are housed over horizontal skylights must be protected from outside air currents, and planned to have sufficient surface to radiate the resultant heat from the lamps.

In general, the failure to obtain satisfactory results over a period of time from installations of this and allied types, is due to improper or inadequate maintenance of the system.

If, however, the location of the control room in the power house structure is of such a nature that the buildings will not allow of skylight construction, excellent results may be obtained by the use of the following type of lighting installation. By the use of indirect luminaires, sufficient intensity for the accurate manipulation of the various control switches may be obtained. Too high a value of intensity of illumination should be guarded against for the general illumination of the room, in order that the attractive power of the various luminous bulls' eyes is not nullified.

In addition to this general illumination, the meter board may be locally illuminated by angle type reflectors, installed beneath the switch bench as illustrated in the sketch. This type of lighting will entirely do away with the annoying specular reflection from the various meter glasses, which is so prevalent in the average control room.

The area between the feeder relay and meter panel should be provided with ample means for sufficient illumination necessary in the repairing and changing of connections. In planning the position and hanging height of the various units, consideration must be given to the fact that they must not at any time be visible to the control room operator, when carrying on his duties in front of the various panel boards.

An opaque reflector is best suited for this purpose, in order that light from the lamp cannot be transmitted through the reflector, increasing the ceiling brightness behind the panel board. In order to insure cleanliness in this area, the light which may perhaps be wired on the emergency circuit, should be kept burning at all times. The remainder of the units may be operated by three way switches at each end of the panel board enclosure.

In the distribution room we may generally find conditions more favorable for illumination of the board proper, in that the operator may remain seated at his desk throughout his shift. The requirements being that sufficient intensity be provided over the distribution map panel making all station names and line markings legible and not detracting from the visibility of luminous markers.

This desirable illumination of map panel may be provided for by angle type reflectors of suitable size or shape, depending upon the size and shape of panel installed in a decorated cove. The light opening would be parallel to the panel and covered with a diffusing glass. In cases where the panel has a flat finish rather than an oiled semi-gloss, the diffuser may be left off.

Where conditions are such that the ceiling height is great enough the angle reflectors may be recessed in the ceiling, covered with a horizontal diffuser. When installing ceiling lights, it is essential to remember that these must not come within 17½-deg. angle of vision. The desk area may then be illuminated by suitable local lights giving sufficient illumination for ease of making records.

Suitable general illumination throughout the room, necessary for safety and maintaining of sanitary conditions, may be obtained from either totally indirect or semi-indirect luminaires, these being so wired that there may be a low intensity available for general duties and a higher intensity for inspection and repairs.

Motor Operates After Being Under Water

SATISFACTORY OPERATION after being submerged in mud and water for two months is claimed in a recent example of unusual motor service. The instance cited concerns equipment owned and operated by the Ward Sand & Gravel Co., of Detroit.

This company installed on one of its barges two 500-hp., 2300-v., 514-r.p.m. pump motors with magnetic speed regulating control, together with a number of auxiliary small pump motors, all made by the General Electric Co. The 500-hp. motors were direct-connected to centrifugal pumps for dredging gravel and sand. In October, 1922, the barge sank, as the result of an accident, and the entire electrical equipment, together with the pumps, slid off the barge into 35 ft. of water. After a number of days' delay necessary for procuring equipment, the machinery was raised piece by piece. Cold weather came on and the work was finished through the ice. The motors themselves were finally removed in December, after having lain in mud for two months.

One of the large motors was found to have its frame broken entirely across and nothing but the rotor was saved. The other motor, together with the small auxiliary motors, transformers, etc., were thoroughly cleaned and dried. None of these motors were rewound and all have since been operating satisfactorily.

IN 1821 SEEBECK discovered that if two wires of dissimilar metals be joined at one end, and this end be immersed into the heat while the cold ends outside are connected to a sensitive voltmeter, the meter will show that an electric force is causing a current to flow in the metallic circuit. The two wires immersed in the heat are called a thermocouple which is usually connected by a pair of flexible leads to an indicating or a recording pyrometer which is kept away from the heat.

Facts Regarding the Use of Reactors*

FACTORS AFFECTING RELIABILITY. EARLY WEAKNESSES AND MEANS TAKEN TO ELIMINATE THEM. BY W. M. DANN†

GOOD VOLTAGE regulation was the aim of the electrical engineer in the early days when generating units and systems were small compared to those to which we are now accustomed. Low power factor was the great influence which operated against this ideal. Reactance was the element that produced low power factor. Consequently, reactance was a thing to be eliminated as far as possible.

When generating units and transmission systems became larger and more extensive, voltage regulation began to be of somewhat less importance. The heavy currents developed at times of short circuit became a matter of concern. Gradually reactance began to be recognized as the solution for preventing destructive short circuit currents and the present extensive use of the current limiting reactor is a natural accompaniment of the growth of the modern power system.

Reactors are desirable only insofar as they are strictly reliable protective devices. Their cost and energy losses are undesirable and they take up valuable space.

Moreover, the highly magnetic field which is depended upon for it to function may be the cause of troubles in operation. Service experiences, however, in the past few years have enabled manufacturers to offer reactors that are entirely reliable and in large generating systems they are practically indispensable.

EARLY INSTALLATIONS

The first example of current limiting reactors, or "choke coils," placed in the circuit to guard against the destructive effects of heavy short-circuit currents, was in the Cos Cob Station of the New York, New Haven & Hartford Railroad, as far as the author's recollection goes. Little or nothing was known at that time about the practical design of air-core reactors, while the reactance determination of generators was well understood. As a result, these first coils were made with an iron core and with extremely large air gaps which again were similar in general form to the small air gaps of a generator. The punchings were made up with slots to receive the coils, which were very similar to those used in a generator armature. The iron part of the magnetic circuit was worked at an extremely low normal density, in order to keep the density in the core below the saturation point under short circuit conditions. As a result, these reactors gave a practically straight line voltage characteristic from no-load current up to the short-circuit current. The general construction of the reactor is shown in Fig. 1.

The second installation of current limiting reactors, as the author remembers it, was made by the Commonwealth Edison Co. of Chicago. No magnetic material was used in their construction. They were made up of bare stranded copper cable wound in cylindrical form on a concrete core with the layers spaced by means of treated wooden strips.

When engineers first turned their attention to the problem of providing inductance for current limiting purposes, it was realized that the reactor would be subjected to high electrical and mechanical stresses when short circuits occurred. It was appreciated that on account of its concentrated inductance, high-frequency disturbances would throw great voltage stresses on the reactor, especially on its end turns, but the real magnitude of these stresses was more or less unknown.

It was also recognized that the mechanical stresses in a current limiting reactor would be extremely large, on account of the extremely large number of concentrated ampere turns under short circuit conditions. Mechanical stresses vary with the square of the ampere turns and they depend upon the degree to which these ampere turns are concentrated or broken up into groups. In a generator, the ampere turns are distributed over the entire periphery of the armature. In a transformer they are broken up into a number of groups and in the primary and secondary groups these ampere turns cancel each other to a great extent, since the currents are in opposite directions in the high-tension and low-tension windings. In a current limiting reactor, however, the current flows in only one direction and the ampere turns are highly concentrated, resulting in mechanical stresses of enormous magnitude.

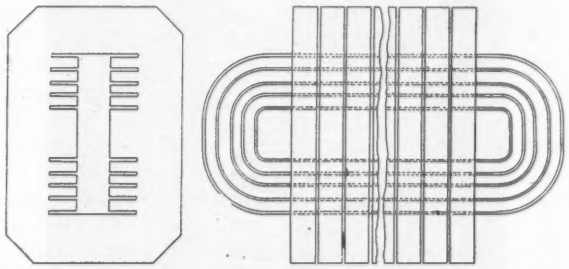


FIG. 1. IRON CORE REACTOR USED BY THE N. Y., N. H. AND HARTFORD R. R. IN THE COS COB STATION

These forces are in such a direction that the tendency is to make the coil enclose a greater total flux, that is, they tend to increase the diameter of the coil and shorten its axial length. The forces tending to increase the diameter produce a tensile stress in the conductors of the coil. The tendency to shorten the axial strength creates a compressive stress on the spacers between the conductors and bending stresses in the conductors themselves. If special precautions were not taken to guard against them, the strong magnetic field that permeates the coil, due to the large number of turns in the reactor, would produce prohibitively large losses within the conductors. A solid conductor, for instance, would give rise to very great eddy current losses within it and these losses would multiply rapidly if the diameter of the conductor were to be increased. For these reasons, a finely stranded cable is the obvious conductor for a current limiting reactor and the smaller this cable can be made practicably, the better is the conductor from the point of view of low eddy current loss.

Using a small cable requires that a number of them be employed in parallel for currents greater than the

*Paper presented at the recent Annual Convention of the A. I. E. E., Chicago, Ill.

†Westinghouse Electric and Manufacturing Co.

capacity of a single conductor. The danger of paralleling circuits in the presence of a strong magnetic field, varying in intensity at different points, will immediately be apparent to one having experience in such matters. In order to avoid unequal division of current or circulating current in the cables, the Westinghouse Company uses a special method of winding for paralleled cables, whereby each conductor passes through a series of positions with respect to the magnetic field which are exactly duplicated for every other conductor in parallel with it. This is accomplished by transpositions in the slots when winding.

As an illustration of this method of winding with two cables in parallel, one cable is carried around one-half the circumference of the inner row of slots in the first layer, and at that point transposed to the next row of

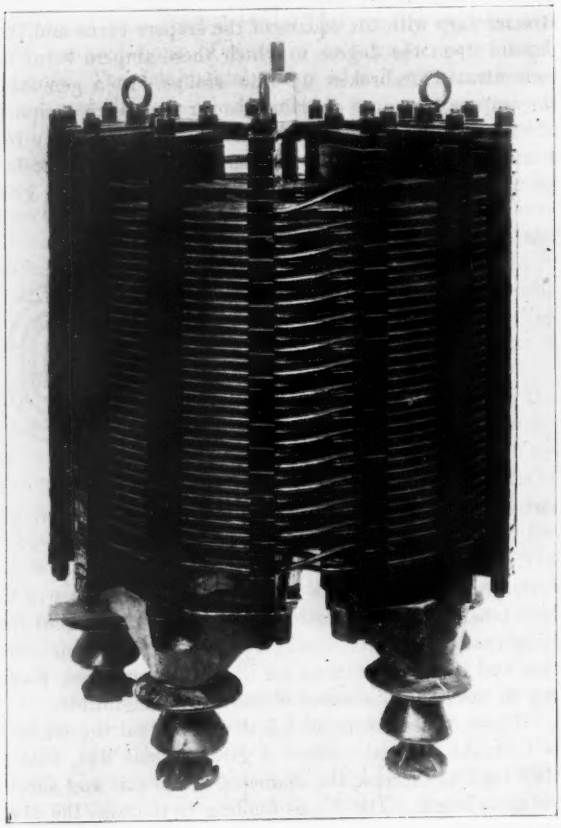


FIG. 2. A MODERN WESTINGHOUSE CURRENT LIMITING REACTOR

slots. The second cable is started at this point in the inner row of slots and is carried around through the second half of the circumference. Consequently in the circumference of the inner row of slots the two cables pass through the positions in the structure which are identical with respect to the magnetic field and they are exposed to the same integrated magnetic conditions. This method of easy transpositions from one row of slots to the next is carried out through the entire structure and the condition of equal resistances and equal inductances in the parallel conductors is accomplished. Unequal division of current in the paralleled paths is in this way effectively eliminated. This method of winding may be employed for any reasonable number of cables by making the number of columns of cleats a multiple of the number of cables used.

The strong magnetic field also causes magnetic forces between adjacent conductors in the winding, especially those close to the top and bottom of the coil where the accumulative effects are greatest. These forces are guarded against by placing the spacer supports between conductors close enough together to keep the maximum forces within the strength of the conductors. Shortening the length of the span between supports must not be carried too far, however, for the greater the number of supports, the less is the radiating surface of the conductors and the higher the operating temperature. The size of the conductors and the arrangement of the structure used must be selected to give full consideration to both of these conflicting factors.

A fairly high operating temperature is permissible, considering the fireproof construction of the modern current limiting reactor; however, the operating temperature at normal current is often of minor importance compared to the temperature reached during short circuit conditions. When a very heavy current flows for a short time, the copper must store up the vastly increased energy loss and it appears as a rapidly increasing temperature. The structure in supporting the cables must for this reason provide for the expansion of the conductors at the time of short circuit.

The thermal duty of a reactor can best be appreciated by considering a specific case, for instance, a coil having a reactance of three per cent under normal conditions. Under short circuit conditions, assuming no other reactance in the system, this coil would carry 33⅓ times its normal current. The thermal results, like the mechanical stresses, vary with the square of this current, and the temperature will immediately start toward the point corresponding to something over 1000 times the normal heat units. While this rapid increase of temperature lasts over only a comparatively short period, the temperature reached at the end of the period is often the determining point in designing a reactor from the point of view of heating. The 5 per cent reactor would be designed with a higher normal operating temperature than the three per cent coil, for the heat units developed in such a coil at the time of short circuit, again assuming no other reactance in the system, would be 400 times normal rather than 1000 times. Consequently, it is reasonable to neglect the normal operating temperature in writing specifications for current limiting reactors, except in cases of reactors for a high value of inductance where the short circuit current is not a great many times the normal current. The designer's chief interest in the normal operating temperature relates usually to its effects on the temperatures reached under short circuit conditions.

There are various viewpoints among engineers as to the length of time during which a current limiting reactor should carry short circuit current without failure due to excessive temperature. The extreme point of view in one direction would be that the reactor should be the weak link in the chain and, like a fuse, should fail and open the circuit before the other apparatus can be affected. Most engineers will agree that the premeditated interruption of a heavy alternating current by means of the failure of a highly inductive device like a reactor would be an undesirable thing.

An extreme view in the other direction is that the reactor should have thermal capacity in such abundance

that it can withstand its short circuit current for a period as long as ten minutes. The point of view for such an opinion is based on disturbances of record which have lasted even longer than ten minutes before the source of the trouble has been found. Reactors designed with such thermal capacity would be so expensive and would occupy so much space that they probably would not be practicable.

Between these two viewpoints is a middle ground where recognition can be given both to the protective function of the reactor and to the practical considerations of dimensions and cost. The maximum current that can flow through a reactor is that which would obtain if full line voltage were applied across its terminals with no other impedance in the circuit. If a reactor were required to withstand such a current for a period of five seconds, it would represent a fair compromise between the cost and dimensions of a reactor having greater thermal capacity and the protection which such a period of time would provide for the system.

The first of the air-core current limiting reactors built by the Westinghouse Electric & Mfg. Co., were made in 1913. They were wound in the form of a cylindrical coil with pancake layers of bare stranded copper cable laid in grooved spacers of treated hard wood. The columns formed by these spacers were bolted together with brass tie rods. Insulating supports or feet at the bottom and a terminal board at the top completed the structure. Ordinary transformer practice was followed in designing the terminal board, except that greater spacing was provided between the terminals than was used in transformer practice. The conductors were soldered into the terminals which were clamped between nuts at the lower end of the studs.

It is clear now that the type of construction used in these original designs was fully strong enough to withstand the mechanical shocks of short circuit. Rather elaborate factory tests were made shortly after the first coils were built in an effort to find out whether the limit of mechanical strength of these coils could be reached. A 15,000-kv.a. generator was short circuited a number of times with increasing excitations with a single reactor in circuit and again with a bank of three reactors, and tests made to the limit of the generator excitation failed to find any weaknesses in the design. Large short circuited currents were produced during these tests and the magnetic forces within the reactor were correspondingly high. For determining the fitness of the design for service on a very large system, such tests are necessarily inconclusive, but service records since that time have abundantly proven that the design is adequate, at least for short circuit currents as we know them up to the present time. The same general arrangement of windings and structure has been used ever since by the Westinghouse Company.

Troubles that have occurred in service have been due mainly to an under-estimate of the excessively high transient voltages that are set up by disturbances in the system and of their effects when concentrated upon the reactor. It was soon found that these voltages must have been as high as 50,000 v. across the reactor when connected in an 11,000-v. circuit, judging from the distances over which they jumped. This voltage manifested itself principally across the end turns of the coil and across the terminals when they were placed together at one end of the reactor.

Another trouble early encountered was found to be due to the metallic tie rods used to clamp the columns of spacers. Surge voltages found a path from conductors at one end to conductors at the other end across the spacers and through these metallic rods, short circuiting the coil.

A few cases of mechanical weakness in the insulating feet and of flashover to ground of insulators that were inadequate also occurred. Trouble of a different kind developed in one or two instances due to soldered terminals which failed and opened up the circuit within the reactor, causing considerable burning due to arcing.

One by one all of these weaknesses have been eliminated. Through the troubles which have occurred in service, the modern reactor has been developed to the point where it is a protective device having the mechanical sturdiness and the electrical strength to carry out its function successfully and to justify its use.

Summary of Elements of Design of the Reactor

The principal elements that contribute to the strength and efficiency of the modern reactor may be briefly summarized as follows:

1. Finely stranded cables of small diameter keep to a minimum the stray losses within the conductors due to the magnetic field. Paralleled sections of windings are used where necessary to carry the current and retain this feature. By reason of the special method of winding, these paralleled lengths of cables have the same resistances and the same inductances, and extra losses, due to unequal division of current, are eliminated. As a final finish, the complete reactor is dipped and baked a number of times in a fire resisting enamel. This enamel permeates the strands of the cable and helps further to reduce the stray losses. It also serves to stiffen the conductors.

2. Extra spacing of end turns eliminates danger of flashover, due to high-frequency transient voltages at times of disturbances on the system.

3. Fireproof composition spacers molded under great pressure form the supporting structure. The slots into which the cables are laid in the winding operation provide sufficient clearance to permit expansion of the copper, due to the rapid heating at the time of short circuit. Wood rods of treated straight-grained hickory are used to clamp the columns of spacers together. Being entirely enclosed in the fireproof spacers, these wooden rods do not form an inflammable element.

4. One terminal is placed at one end of the coil and the other at the opposite end to eliminate the danger of flashing across terminals.

5. Normal current densities are set low enough to keep temperatures within same limits when the sudden heating, due to heavy short circuit currents, develops.

6. Solderless clamped connectors are used to connect the ends of the winding to the terminals. Contact nuts, made with a lug having a radial saw-cut through it, are arranged so that they can be bolted after being tightened. Once set, they are permanently locked in position. Brass tubes placed over the leads between the winding and the point of connection to the terminal studs gives the necessary stiffness to these leads to eliminate troubles due to mechanical forces exerted on them when heavy short circuit currents flow.

7. Extra heavy pin-type or pedestal-type insulating supports given the necessary mechanical and electrical strength to eliminate troubles due to mechanical breakage or to flashover to ground.

High Lights of World Power Conference*

IMPORTANCE OF RECLAIMING BY-PRODUCTS OF COAL IS EMPHASIZED. ELECTRIC DISTRIBUTION SYSTEM PRACTICE. BY ARTHUR L. RICE

MANY PAPERS were presented at the World Power Conference dealing with the better use of fuels. Two main general propositions were considered; first, removing volatiles and those constituents which are more valuable for other purposes than for power fuel from raw coal; second, better utilization of solid fuels by more careful preparation and burning. In the first group were papers by Dr. Franz Fischer, on Conversion of Coal into Oils; by W. Gordon Adams on Liquid By-products of Coal; by Dr. C. H. Lauder, on Low Temperature Carbonization. In the second group were included, Economic Power of Solid Fuel, by Leonard C. Harvey; Coke for Power, by E. W. L. Nicol; Co-ordination of Fuel Supplies, by E. W. Smith; Preparation and Combustion of Fuel, by C. F. Hirshfield. Since, as was to be expected, there was much covering of the same ground by different authors, it seems desirable to review these papers by groups rather than singly.

DISPOSITION OF BY-PRODUCTS ONE DRAWBACK

While low temperature carbonization was recognized to be desirable for the production of domestic fuel, it was felt that no complete solution had been reached and that, if all central stations went to such a system, it is doubtful if a profitable market could be found for the by-products. Products to be sought are tar, motor fuel, gas, ammonium sulphate.

To get the most motor spirits, Dr. Fischer advocated working at 300 to 450 deg. C. and cooling the material distilled off as soon as possible. He has found that compression of carbon monoxide and passing it over iron filings at 410 deg. C. will produce an oil which he calls "Synthol" which is superior to benzol as a motor fuel. By repassing over the filings at low temperature, as much as 30 per cent of the heat value of the gas can be secured as synthol, leaving a gas of high heating power for industrial use. An interesting suggestion was that by an adaptation of the process it may be possible to produce motor fuel from water and the constituents of air if suitable power resources are available.

Low temperature treatment was classified by Dr. Lauder as the gas-works method, carried on by external heating at 1000 to 1300 deg. C. and the coke method by open heating at 1200 to 1300 deg. C. The yield per ton of coal is about 3000 cu. ft. of gas having a heat value of 1000 B.t.u. per cubic foot, 13 to 20 gal. of dry oil; 1 to 1.6 gal. of motor spirits from the tar and 1.4 gal. from the gas, a total of 3 gal. per ton of coal. The residue solid fuel will be about 14 cwt. per ton, having 7 to 10 per cent volatile matter. Hot gas carbonization yields 20,000 to 25,000 cu. ft. of gas having a heat value of 230 B.t.u. per cubic foot.

Contrasting the methods, Mr. Adams gave the yield of tar per ton of coal as 10 to 14 gal. for retorts, 8.5 gal. for coke ovens and 20 gal. for low temperature carbonization. Distillation of tar from the gas and coke industries would give about 3.5 million gallons of motor spirits a year in Great Britain.

FERTILIZER SUPPLY MIGHT BE SOLVED BY COAL CARBONIZATION

Of ammonium sulphate, Mr. Harvey stated that 15 lb. was lost for each ton of coal used in the raw state. This is an important fertilizer constituent and he suggested that the waste from mine dumps, which in itself contains some fertilizing elements, could, after washing to remove combustible, be mixed with the ammonium sulphate to form a commercial fertilizer. He estimated that if 12,000,000 T. of the coal used in the United States be so treated it would replace all nitrate now imported from Chile, besides giving 24 million gallons of motor spirits and 8 million tons of smokeless fuel.

Mr. Harvey estimated that under present conditions, 90 per cent of the "cost" of coal is lost. This can be bettered by cutting down waste at the mines, more careful working of seams, more careful clean up of slack, washing of slack and waste. In England, as pointed out by Mr. Smith, the average haul of coal from mine to furnace is 50 mi. and the cost $1 to $1.25 a ton. By the washing of power coal, the ash can be reduced from a content of 10 per cent to one of 7 per cent and the hauling of 4,000,000 T. a year avoided. Also, by drying, the present moisture content of 10 per cent can be reduced to 5 per cent, still further cutting the weight to be hauled. With the longer hauls in America, the saving would be of the same percentage order, but much larger in dollars saved. The washings can be utilized as mine fuel, also, thus releasing much coal for shipment. Mr. Smith estimated the coal lost in mine faults and pillars as 30 per cent of the amount in the seams and that 25 per cent of the slack brought down by blasts is now stowed in mine galleries.

If all waste heat from gas works were utilized, Mr. Smith estimated that it would furnish 1/7 of the electric power used in England. Also, if used to best advantage, the surplus gas from coke ovens would supply 36 per cent of that needed for town use. As a matter of fact, part of this is used about the works so that 12 per cent is available, but most of that is wasted. In this connection it was shown that if a house uses all gas for heating and cooking, one ton of coal will be required to furnish 15,000 cu. ft. of gas with heat value of 500 B.t.u. per cubic foot. The same heat can be supplied by 10,000 cu. ft. of gas and ⅓ T. of coke, both made from ⅔ T. of coal, a saving of one-third in the raw coal used. As the coal for domestic use is 15.2 per cent of the total for the country, this saving is well worth while.

COKE FOR POWER PLANT FUEL

Coke can be used as a power fuel to good advantage and the by-products saved will help out the diminishing petroleum supply. Mr. Nicol pointed out that petroleum can be used as a substitute for coal, but the reverse is not true. The world production of coal is 1,500,000,000 T. and of petroleum 118,000,000 T., so that it is wise to make

*This is the concluding article of a series summarizing the discussions at the Power Conference. The first article appeared in the Aug. 1 issue and the second in the Aug. 15 issue.

the coal help conserve the petroleum so far as possible. At present only 20 per cent of the coal is treated in gas works and by-product coke ovens. The coke for power use can be made from non-coking coal and should be of nut size or breeze. It can be burned on a chain grate stoker or in pulverized form with low excess air and giving a high furnace temperature. In the Sandwich system, coal and coke are used in layers, fed from separate hoppers to a chain grate, in equal proportions, the coal on top. It is a low grate slack. With coke alone, an evaporation of 9.3 to 10.5 lb. is obtained from and at 212 deg. F. while, with coal-coke mixture the from-and-at evaporation is 9.2 lb.

Summarizing, the suggestions for fuel saving are more careful mining; recovery of all combustible from the mine product, using the unsalable waste for mine fuel; reduction of incombustibles before shipping coal; gasification or carbonization of most coal before burning; in bringing to use such methods as will ensure greatest possible recovery of heat content.

Electrical Distribution

In the matter of electrical distribution, the opinion was repeatedly expressed that wide and certain supply was of more consequence than capital cost. As W. L. Murray put it, "The presence of power is more important than the cost of power."

In addition, however, it is desirable to keep cost low and Charles H. Merz called attention to the use of high-voltage cables, even as high as 130,000 volts being expected, so as to connect overhead transmission lines direct to underground distribution and supply and avoid the cost of substations and switchgear. Also, more reliable cables and lines will do away with need of duplication and protective devices. Reliability, even at high cost, is cheaper than duplication, he said.

In Sweden the trend has been in the same direction and toward abandoning duplication, lighting protection and choke coils. Single, high-voltage lines are used on wood poles but money is spent to get the best possible machinery and equipment in stations. The population is sparse and cost of the system must be kept low.

In the Rand, Africa, a balanced relay system is used with explosion pot on the switches so as to quench the arc and reduce the cost of the switch gear.

Mr. Summerhayes of the General Electric Co. gave data as to use of automatic substations which operate at 2300 and 6600 volts without an attendant. Such operation was started to reduce expense but experience has shown that they are more effective than manual stations and a 10,000-kw. station is now under consideration, also another with two 9000-kw. units.

Closed system ventilation is being used for generators on all new large units, hydrogen being found desirable as the cooling agent because it reduces fire risk and the corona effect in hydrogen occurs at higher voltage than in air. When fire does occur, steam is used to smother it.

Automatic voltage regulation is much used in hydraulic plants but less in steam plants on account of the greater number of the feeders. Such regulations will probably increase because of the better operation of stations connected in parallel when such a system is used.

In Canadian hydraulic plants, as stated by Mr. Gaby, friction in water ways leading to the wheel is reduced by a cement lining. Efficiency of 93.6 per cent in the turbine is thus secured and, for the plant, 91 per cent.

Transmission lines should be designed and built with careful engineering and should be able to resist high stress. Continuous service is more important than cost. Causes of trouble given by Guido Semenza are: Short circuits, breakdowns of machinery, or of insulation, lightning, poor regulation. Interruptions mean costly repairs, loss of revenue and tendency to develop small independent plants not connected to the system. By use of relays a system 400 by 200 miles is covered in Canada having a system 4000 miles long and connected capacity of 1,000,000 kw. Interruption has been reduced to 1 to 2 min. a year on parts of the system. Automatic substations have not been found to fulfil completely all requirements but, in conjunction with manual operation, give very good results.

Closing Sessions

At the final sessions, O. C. Merrill acting as chairman, called attention to the free contribution of data that had been made as a tribute to friendly cooperation in science. Financing of power development is a speculation on an investment according as conditions of development and operation are guessed at or known. Electricity is one of our most important tools in dealing with social problems and will allow of decentralization of industry and better conditions for workers. Meeting of engineers of all countries in a friendly way will contribute to progress in engineering and will help bind together the peoples of all countries and thus work for the prevention of future misunderstandings and wars.

These sentiments were emphasized by movers and seconders of the resolutions which had been prepared by the executive committee. The first resolution was for the continuance of the work of the conference and formation of a permanent institution such as may best fit the activities to be carried on. Each country to maintain a permanent national committee and the executive committee to continue for the time being to carry on the work of the conference. Each country to be represented on the International committee by a delegate or a correspondent and this International committee to meet within a reasonable time to devise a plan for a permanent organization and a scheme which shall avoid interference or overlapping with the functions of any existing international organization. Next meeting of the conference to be decided upon by the International committee but, so far as practicable, future conferences to be held in different countries. This resolution was moved by Italy and seconded by France, the United States and Canada.

In the second resolution, it was given as the opinion of the conference that the world's greatest need is more production and manufacturing activity among its peoples under conditions that will promote individual prosperity and happiness and that this can be largely achieved by fuller development of power resources and establishment of the most economical means for general distribution and utilization of energy. This was moved by Great Britain and seconded by the United States.

A final resolution for the purchase and preservation of Heathcote Hall, the residence of James Watt, containing his workshop exactly as he left it was referred to the executive committee for such action as was found wise and possible.

Controlling Combustion by Temperature

FURNACE AND EXIT GAS TEMPERATURES CONTROL DAMPERS AND FUEL FEED THROUGH THERMOCOUPLES. BY GORDON SIMMONS

WHEN the temperature of the flue gases leaving any heat absorption apparatus exceeds that of the atmosphere, fuel is being wasted. The percentage of fuel wasted is proportional to the difference in the temperature of the flue gases and that of the atmosphere.

According to Gebhardt, this loss is usually the greatest of all losses of heat in boiler plants, and has been estimated as ranging between 12 per cent and 40 per cent of the total heat generated. The magnitude of this loss depends chiefly upon air dilution and the temperature at which the gases are discharged. Flue temperatures less than 450 deg. F. are seldom experienced unless in connection with economizers, and the air dilution is ordinarily in excess of 50 per cent of the theoretical requirements, hence the loss from this cause may range from 12 to 40 per cent of the total heat generated. In excellent practice it is not far from 12 per cent with a general average of from 20 to 25 per cent.

If, when economizers are not used, the losses under the best conditions are around 12 per cent and in average practice are around 25 per cent, it is evident that in general there is possibly a saving of 13 per cent and in some cases much more than that amount. When economizers are used, the losses are smaller, but are still of considerable magnitude. These large losses can be reduced by giving proper attention to the flue gas temperature.

In order to understand the causes of excessive stack temperature, it is necessary to consider the fundamentals of steam generation. The equipment used for the generation of steam consists essentially of two parts, the furnace and the boiler. It is the function of the furnace to generate heat by the combustion of fuel and it is the function of the boiler to absorb the heat generated in order to evaporate the water into steam. Even under ideal conditions, only part of the heat generated by the furnace is available for absorption by the boiler, the principal part of the remainder being lost up the stack. Anything that reduces the absorption of heat by the boiler allows a greater proportion of the heat to go up the stack, which increases the losses.

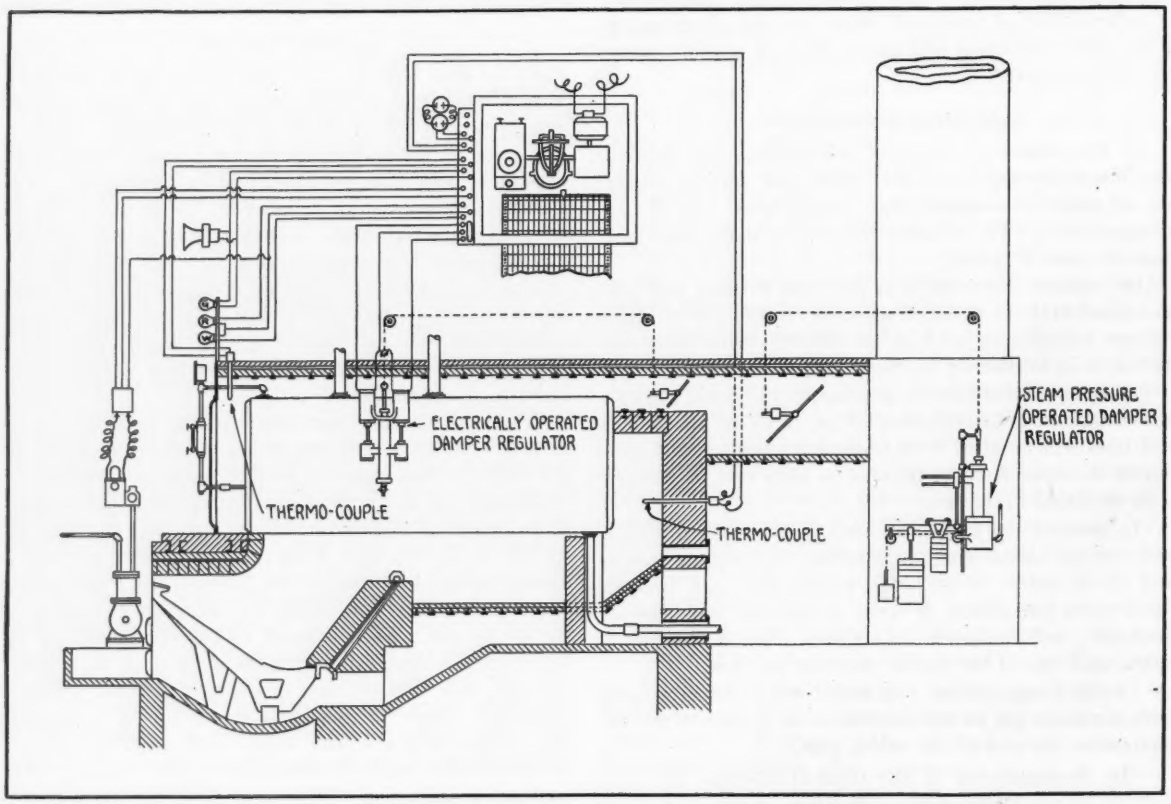


FIG. 1. APPLICATION OF COMBUSTION CONTROL BY TEM- PERATURE TO AN H. R. T. BOILER

Of the total heat absorbed by the boiler, part is radiated to the tubes from the fuel bed and part is carried by the gases to the tube surfaces. In any particular equipment the relative amounts of heat transferred in these two ways depends largely upon the absolute temperature of the fuel bed. The relative amount of heat transferred by radiation increases rapidly with this absolute temperature. This is so because the amount of heat carried by the gases varies directly with the temperature whereas the heat transferred by radiation varies as the fourth power of the absolute temperature.

Power plant engineers recognize that high exit gas

temperatures indicate large losses of heat, but the exact significance of these temperatures is not always clear. It can be shown that high stack temperatures and the large losses they represent are caused by excess air, dirty boiler tubes and leaky baffles. High exit gas temperatures can therefore be prevented by proper operation and maintenance.

An excess of air causes a lower temperature at the fuel bed. This does not mean that the temperature of the gases leaving the boiler will be lowered also. Actually it has been shown that low initial temperature in a water tube boiler results in an increase in temperature of the exit gases. This is due to the fact that the lower temperature at the fuel bed reduces very greatly the heat transferred to the boiler by direct radiation, and allows a much greater proportion of the heat to be carried by the gases. The net result is an increase in the temperature of the gases leaving the boiler and entering the flue. Actual experience has shown that excess air causes higher stack temperatures in fire tube boilers also. There is, of course, a limiting condition of load on the boiler below which, excess air does reduce the temperature of the gases leaving the boiler. Were this not so, a banked boiler would have the higher stack temperature. This limiting condition of load on the boiler is far below the efficient load for any boiler and in this discussion can be ignored. The apparatus to be described hereafter, when this condition obtains, gradually closes the individual boiler damper until the excess air is reduced to the proper amount.

When operating a boiler at reasonable rating, the increase in stack temperature due to excess air is material and not merely theoretical as can be seen from the figures in the accompanying table taken from the 1921 report of the Prime Movers Committee of the N. E. L. A.:

INCREASE IN STACK TEMPERATURE DUE TO EXCESS AIR

Per cent Excess Air	Furnace Temp. Deg. F.	Exit Temp. Deg. F.	CO_2 Per cent
40	2700	539	13
80	2300	608	10
Differences	-400	+69	-3

It will be seen from the table that an increase in stack temperature of 69 deg. F. corresponds in this case to a decrease of 3 per cent in CO_2 or an average of 23 deg. F. for each per cent of CO_2.

In the case of 40 per cent excess air the heat loss is approximately 12.5 per cent of the total heat generated, and with 80 per cent excess air the heat loss is approximately 18 per cent of the total heat generated. Accordingly, a reduction of approximately 13 deg. F. in the stack temperature results in a 1 per cent saving in the fuel bill.

The reason why high stack temperatures caused by excess air represent such a large loss can be seen from the following equation for the loss:

$$\text{Loss} = .24W\ (t_s - t)$$

in which

W = weight of flue gases

t_s = temperature of flue gases

t = temperature of air entering furnace

.24 is the value usually taken for the specific heat of the gases.

It will be seen that the loss increases with the weight of the flue gases and with the temperature of the flue gases. Inasmuch as excess air increases both the weight and the temperature of the flue gases, it has really a double effect in increasing the loss.

Even though the furnace is operated with the minimum amount of excess air for proper combustion, the boiler may be still unable to absorb all the heat that it should. The trouble may be due to any or all of the following conditions: 1, Gas side of boiler covered with soot. 2, Water side of boiler incrusted with scale. 3, Defective baffles which allow the hot gases to take a short path to the stack instead of taking their proper path across the boiler tubes.

Another point of considerable importance is that temperature measurement of the furnace and exit gases gives an indication of the CO_2 content and the CO_2 content can be controlled by temperature actuated means. This basic principle, therefore, offers an opportunity for combustion control by temperature, which at the same time will permit an indication by warning signals of inefficient combustion conditions.

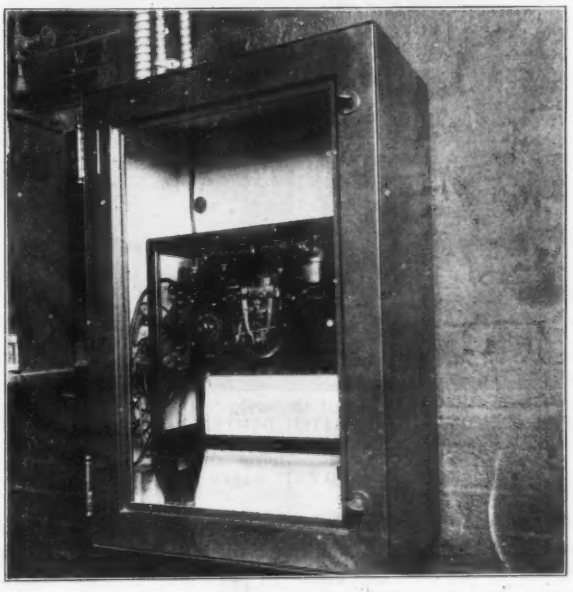


FIG. 2. TEMPERATURE CONTROLLER, WHICH IS ACTUATED BY THE THERMOCOUPLES

Method of Controlling by Temperature

In Fig. 1 is shown a combustion control system which is designed to operate on the above principles. This particular installation is for a horizontal return tubular boiler, with natural draft. The setting is somewhat unique as the air enters the ash pit from the rear of the boiler, is passed under the bridge wall and a part of the air is admitted over the fire through perforated refractory tile on top of the bridge wall as shown.

Two thermocouples, as shown in Fig. 1, are hooked up to a Leeds & Northrup controller shown in Fig. 2. The main uptake damper is controlled from steam pressure by a Mason regulator and the individual boiler damper is controlled by temperature through a special electrically operated Mason regulator, as shown in Fig. 3. The fuel feed is also regulated by the temperature controller.

When the thermocouple measuring the temperature of the furnace gases is properly located to indicate the average gas temperature entering the flues, a temperature variation above and below a definite and limited temperature range can be used to indicate to the fireman the condition of his fuel bed.

This indication is accomplished by mounting directly on the boiler front three signal lights, white, red, and green. If proper combustion conditions are being obtained, a white light will show. This white light is usually set to show for conditions between 13 and 16 per cent CO_2. If furnace conditions are not quite right, the

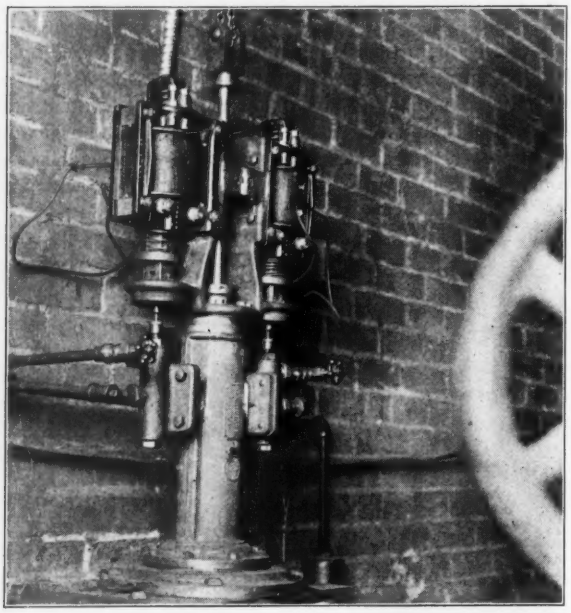


FIG. 3. SOLENOID OPERATED DAMPER REGULATOR WHICH IS ACTUATED BY THE TEMPERATURES FURNACE AND EXIT GASES

red will alternate with the white light, evidencing a falling off of proper furnace conditions, the equivalent CO_2 being below 13 per cent and above 10 per cent. If these conditions are not remedied promptly, but get worse, the red light alone will show and continue to show until proper conditions are restored. This red light is usually adjusted to show for a CO_2 content less than 10 per cent.

In case of excessive stack temperatures, a green light will show and continue to show until the temperature is reduced. As the loss from this source as previously pointed out, is so great and so easily remedied, a klaxon alarm is usually provided which sounds when the stack temperature exceeds that shown by the green light.

Extensions of the signal system can be carried to the chief engineer's office, the superintendent's office, the manager's office, or where desired, insuring attention on the part of the fireman to the information conveyed by the red or green light.

This method of boiler control taking advantage of the established fact that for each proportion of air and coal a fixed temperature of combustion results, provides means for the supply of the proper amount of fuel and air to maintain the determined combustion temperature under the varying conditions of operation. The Leeds & Northrup controller continuously measures the temperature of the combustion chamber and of the smoke box. These temperatures vary with boiler, furnace and coal characteristics and with draft conditions, but the most efficient temperatures are determined for the particular plant and the controllers set to maintain these determined conditions. One of these controllers is necessary for each boiler and once adjusted to its determined temperature requires no further attention.

In Fig. 4 is shown an example of how the CO_2 content of the combustion gases was automatically controlled by the temperature actuated means at one of the stoker operated plants of a large eastern railroad. When the automatic equipment was disconnected to show the result of hand operation, the difference was very marked. A decrease in stack temperature of 43 deg. F. was also automatically maintained for such time as the control equipment was in use.

Usually the location of the thermocouple measuring the temperature of the gases leaving the furnace is calibrated with reference to the furnace temperature by means of an optical pyrometer so that the average furnace tem-

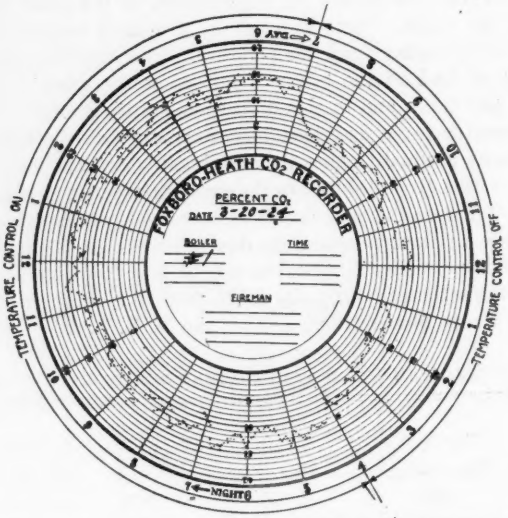


FIG. 4. RECORD OF CO_2 WITH TEMPERATURE CONTROL ON AND OFF

peratures are easily determined. Knowing the furnace temperature and the exit gas temperature, and allowing a certain small percentage for combustible rejected to the ash pit and the heat radiated by the boiler, and knowing the B.t.u. value for the fuel, a close approximation to the combined boiler and furnace efficiency, as well as evaporation per pound of fuel from and at 212 deg. is only a matter of a simple arithmetical computation.

A strip chart is used for recording furnace and exit gas temperatures so that the determinations of average furnace and exit gas temperatures can be easily made. The temperature controller is also equipped for measuring the CO_2 content of a cold gas by means of the difference in thermal conductivity of the gas to be measured, referred to air. This method of gas analysis is a very accurate one and was developed by the U. S. Bureau of Standards.

Direct control of signal lights, air supply and stoker-speed from CO_2 determinations is therefore possible but thermocouples are more rugged than any present form of gas analyzer and for this reason are preferred.

And I Learned About Firin' from Him

REMARKS AND REMINISCENCES OF AN UNUSUAL FIREMAN. BY JAMES T. BEARD, 2ND

I'VE BEEN ROAMIN' 'round the country quite a bit. Worked in 'Frisco, Denver, Chicago, and then drifted East to Pittsburgh, Philadelphia and New York. Kind of a travelin' fireman, I guess.

And I've worked for all kinds of chiefs. Some as knows what they's talkin' 'bout, but somehow can't tell you so's you can understand. You know the kind what grabs a oil can, squirts a gob o' oil in his hands, rubs it, pinches it, smells it, and tells you it's a parry-fin distyllit. Blest if I know what that means, but I *do* know it's a darn good oil for my engine bearin's.

An' I've worked for the other kind, too—the kind what thinks he knows a heap sight more'n he really does know. The kind that's gene'lly blowin' that if the super'ntend' 'ud let him have his way he could run the plant an' save 'em all kinds of dough.

Now I ain't got nothin' agin the man what knows so much he can't talk like a reg'lar feller. I often wish't I had the chancet to go to school and read books. Sometimes I feel kinda sorry, though, for those fellers, 'cause they could get a lot more done in a plant, if they could talk so's we could warm up to 'em a bit. Allers gassin' 'bout B.t.u. an' CO_2. Sounds like my young un learnin' his alpherbet or doin' his sums. Can't make no head or tail out of it. But I've learned a whole lot, just watchin' them kind an' seein' as how they does things.

An' I don't hold no grudge agin the man what thinks he knows more'n he really does. The super'ntend' is gene'lly wise to him. He ain't gettin' away with nothin', not even with us firemen. But I'd have a lot more respeck for him if he'd come out like a man an' say he don't know this, or he don't understan' that.

Sometimes it's really dang'rous in a plant with them kind 'round. They never asks nobody nothin'. If they don't just understan', they goes right ahead, openin' valves an' a-pullin' switches, until some day somebody gets hurt. I've learned a lot from them kind, too—mostly 'bout what *not* to do, if I wants to hold my job through the winter.

I'll never forget the time I wuz workin' in a soap plant in the West. We had a chief what had a college diploma, with all the trimmin's. He wuz a mighty nice feller, though, spite of all that. Me an' him got kinda chummy, that is, I mean, if a body can get chummy with a guy what wears them big rim glasses. He knowed all 'bout CO_2 an' B.t.u. an' them things.

One day he sez to me, "Joe," he sez, "how offen do you clean them boilers?"

I told him they gene'lly scaled up so's we had to clean them 'bout ev'ry two months.

"Too much cleanin', Joe," he sez. "What do you say as we finds out what's the matter with our water softener?"

Well, I'd never worked in a plant before, where they had a water softenin' outfit. So, I told him that me an' Chemistry wuz puffick strangers.

"Joe," he sez, "I'm goin' to learn you all you need to know 'bout that there outfit. Then, if we has any more trouble with it, you can fix it yourself."

Well, I guess he spent purty near two weeks off an' on, tryin' to tell me 'bout it. I can't hand myself no bokays as a student of Chemistry, an', mebbe, it's just as well I never tried to go to college. If I hadn't just nachelly liked that chief I sure would uv told him to take has scale-formin' salts an' go plumb to blazes. I wuz 45 yr. old an' I never knowed they wuz any sech thing as salts, 'cept the kind we used to have on the dinner table an' the kind I bought at the drug store.

But he wuz a durn good scout an' I made up my mind that I wuz goin' to find out what they wuz to this here water softenin' bizness anyway.

An' I found out they's nothin' to it. It's just as easy as rollin' off a log. Hearin' him talk, I thought it wuz worse'n this here Mr. Einstein's theery, what ev'rybody's talkin' 'bout, but nobody knows what it means. But, watchin' him do it, I can't see why anybody could make sech a fuss 'bout sech a simple thing.

All he did wuz to take two milk bottles. He filled one of 'em with water, just before it went into the softenin' tank. An' he filled t'other one with some water just after it left the softenin' tank. Then he gave 'em both to the chemist. Now, I wants to know if they's anything simpler than that.

I wuz kinda su'prized when he told me as how we'd have to let the chemist do the water testin'. But it made me feel like me an' the chief wuz better pals, seein' as how neither of us knowed enough 'bout Chemistry to test water.

An' it wuz kinda satisfyin' to know as how if I ever got in a jam 'bout bad feed water all I had to do wuz to fill up my bottles an' give 'em to the chemist. Made me feel they wuzn't so much mystery stuff to the durn thing after all, an' I told the chief so, too.

"That's right, Joe," he sez, "a engineer can't expeck to be a chemist, too. All he's gotta know 'bout this water testin' bizness is the right place to get his water samples from. He oughta think it out for hisself ev'ry place where they's likely somethin' can happen to the water. Then he oughta take samples at all them places. That's why I took one sample before the water went into the tank an' t'other sample after it come out. If the chemist sez the water is bad after it has come out of the softenin' tank, then we knows as how we ain't puttin' the right chemicals into the tank. Then we puts it up to the chemist an' he tells us what we oughta do."

That's just how easy this here feed water softenin' bizness is. An' if you ain't got a chemist in the plant, it's just as easy to hunt one up somewheres in town.

'Bout a week later the chief comes 'round to the boiler room lookin' kinda glum. When I asks him what's bitin' him, he tells me as how the chemist sez the feed water wuz O.K. and they wuz nothin' the matter with the softener. I couldn't make out for a minit if the chief wuz kiddin' me, or if the chemist wuz kiddin' the chief. Then I give it up.

Anyway, what wuz the use of me clutterin' up my brain with a lotta mystery bunk 'bout feed water softenin'. The boilers got all scaled up ev'ry two months an' it wuz

up to me to clean 'em. So I told the chief to forget 'bout the softener an' I'd get along the same way I allers did.

But my talk didn't cheer him up a bit. Next day he still looked glum an' I could see he wuz worryin' 'bout that durn softener. So I sez to myself if he wuz goin' to worry, it wuz my job to help him get it fixed, so long as he wuz the chief, an' so long as I couldn't help likin' him, spite of his college pedigree.

Well, I did quite a bit of thinkin' that week. Friday mornin' the chief comes into the boiler house lookin' like the mornin' after Saturday night. An' them big rim glasses didn't make him look no better, either. He walks right over to me an' never sez a word.

"Chief," I sez, "I been thinkin' 'bout this here water softenin' since you wuz in here last. It's a cinch we's gettin' good water outa the softenng' tank an' bad water into the boilers."

Right away he gets interested, so I goes on.

"I took a sample of this here water right at the boilers an' sent it to the chemist. He sez it ain't fit for boiler water. Looks kinda strange, don't it, seein' as how the water comin' outa the softener is O.K?"

I could see his face brighten up right away.

"Joe," he sez, "do you s'pose they could be a bypass in that there feed water line?"

Then I tells him as how I had a sneakin' hunch they wuz. An' when the chemist sez the water at the boilers wan't fit, I wuz plumb sure they wuz water gettin' into that feed line without bein' softened. An, then I snooped 'round an' found the consarn thing, with the bypass valve wide open.

Well, I never seen a man so happy in all my life. You'd have never knowed he'd ever been to college, the way he acted. Just like my young un on a Sunday School picnic.

"Joe," he sez, "I gotta take my hat off to you."

That's just the kinda feller he wuz. Never jealous when somebody else pulls off somethin' good. Allers gotta good word for ev'vrybody. Just can't help likin' that kinda feller. Knows more 'bout engineering' in a minit than I'd know in a year.

I allers kinda suspeckted as how he knowed 'bout that there bypass before he started me a-thinkin. But, somehow he wanted me to find it. An' when I finds a coupla more dollars in my pay envelope the next week, I wuz plumb sure I wuz right. But I never could prove it.

Ice Plant Changes to Oil Engine Drive

Pure Water Ice Co. at Waukegan, Ill., Reduces Operating Costs So It Readily Competes With Natural Ice Producers

IN THE NORTHERN part of Illinois there are a great many small lakes which for a number of years had been virtually the one source of ice for the communities in that district. After several mild winters and a resulting failure of the natural ice crop, several business men of Waukegan organized the Pure Water Ice Co. and constructed a plant for the manufacture of ice.

As this was a new venture in a natural ice district, the investment was at first considered somewhat of a risk. This idea was soon dispelled, however, and from the day of starting up the plant has been a success in every way. One great reason for the success of this plant is that changes have readily been made when it could be shown that they would effect a saving. The outstanding change of this kind was that of discarding electric drive in favor of oil engines. This one move resulted in a saving of about 54 per cent when comparing the bills for electric power with those for fuel and lubricating oils for the engines.

As a result of the change no additional attendance labor has been required. The saving mentioned above is of course not clear because there should be deducted from it interest and depreciation charges on the engine installation. The salvage value of the motors is a credit item to be deducted from the installation cost of the engines. The net result after deducting all charges has been a well worth while saving due to the installation of these engines.

These engines have now been installed for 2 yr., during which time there have been no enforced shutdowns and no extensive repairs. Once a month each engine is shut down at a favorable time for a period of about 2 hr. for the purpose of inspecting it.

One motor removed was of the synchronous type rated at 115 hp. and 600 r.p.m. In its place was substituted a 75-hp. Fairbanks, Morse & Co. Y type oil engine which operates at 300 r.p.m. This engine takes the same load that the motor handled, this load consisting of a rather unusual compressor combination. It is in reality a duplex, horizontal compressor which was made by mounting two

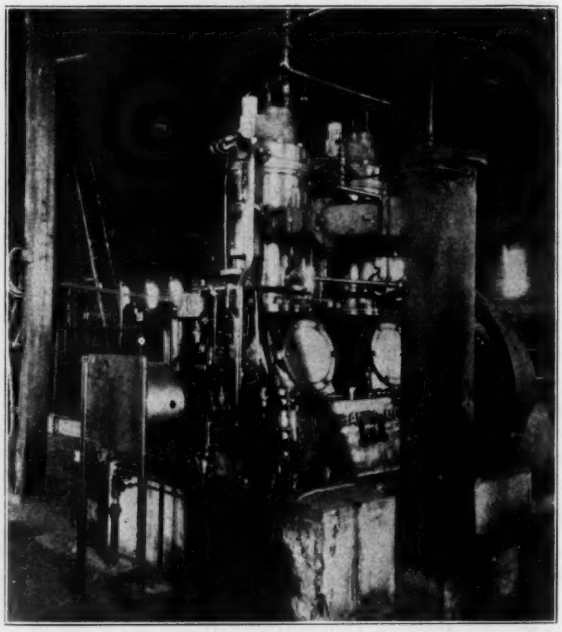


FIG. 1. VIEW OF THE WOLF SIDE OF THE REBUILT WOLF-VILTER COMPRESSOR

single cylinder compressors of different makes on the same shaft. The one side consists of a 10 by 17-in. Wolf compressor and the other side is a 9 by 18-in. Vilter com-

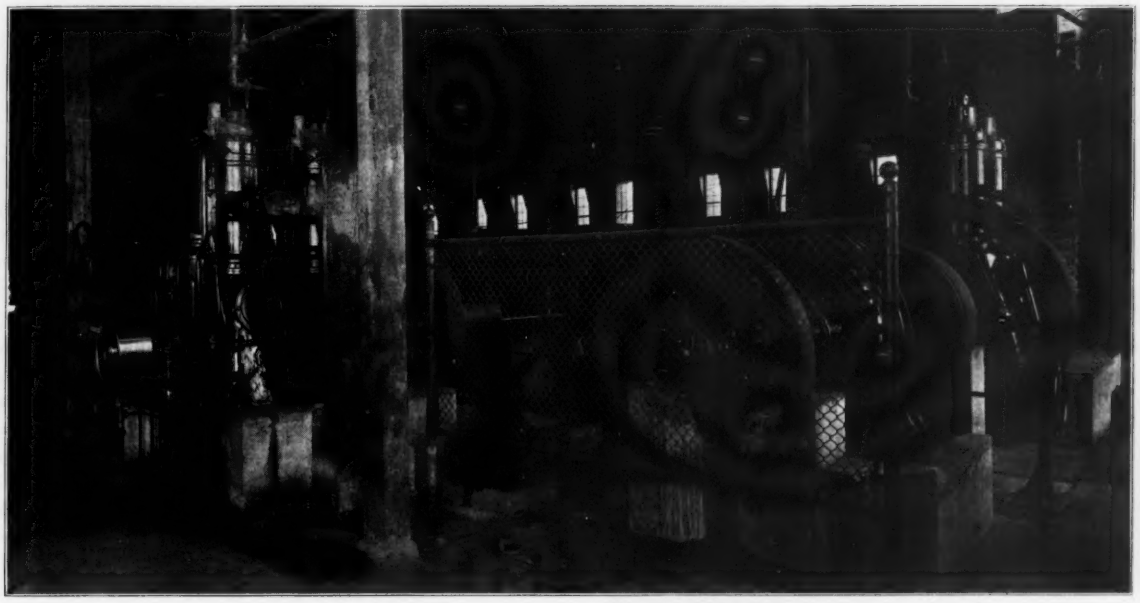


FIG. 2. VIEW OF THE OIL ENGINE INSTALLATION

pressor. Mounted between the two cylinders is a flywheel on a common crank shaft, which is connected to the drive wheel of the engine by a 20-in. leather belt. The centers for this drive are 37 ft. apart.

When it came to replacing the second large motor with a Y type engine it was necessary also to provide an alternator as a source of power from which to drive the numerous small motors about the plant. The motor taken out was rated at 50 hp., 220 v., 3 phase, 60 cycles and 865 r.p.m. The engine installed in its place is rated at 100 hp. and 257 r.p.m. The shaft of this engine is extended so that there is driven from it a 10 by 10 in. York compressor, the alternator and the exciter for the alternator.

Compressor Driven Through a Clutch

Mounted on the engine shaft near the engine flywheel is a pulley from which the compressor is driven by a leather belt. This pulley is provided with a clutch so that the compressor load may be thrown off the engine. The alternator is mounted directly on the engine shaft. This alternator is rated at 60 kw., 220 v., 3 phase, 60 cycles and 80 per cent power factor. The exciter which is rated at 5 kw., 125 v. and 1400 r.p.m. is belt driven from the engine shaft. The clutch, the alternator and its exciter were furnished by Fairbanks, Morse & Co.

Compressed air at 175 lb. pressure is used for starting these engines. This air is provided by two single-stage compressors which are driven by small air-cooled gasoline engines. The exhaust from each engine goes directly into a concrete pit located beneath the floor. The atmospheric exhaust pipe, which is of riveted spiral-steel pipe, extends from the pit through the roof, and at the top of this pipe is mounted a muffler. As might have been expected there was some objection in the neighborhood to the sound of the engine exhausts when they were first started. Lately, however, a night-hawk found, beneath the shelter of an exhaust pipe flashing, a good warm place to lay and hatch her eggs. She evidently did not find the noise objectionable.

FIG. 3. GENERAL VIEW OF THE FREEZING TANK ROOM SPRAY NOZZLES

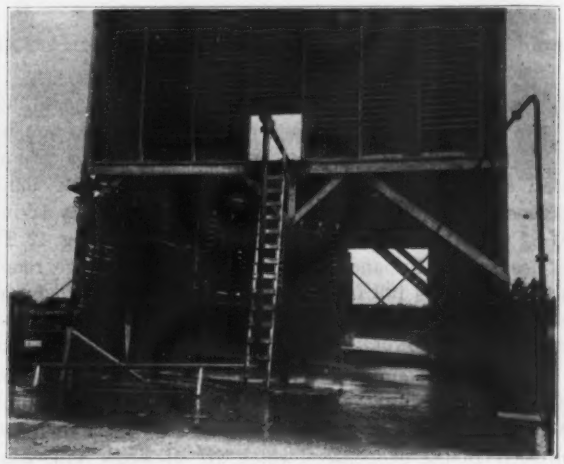


FIG. 4. TWO CONDENSERS ARE LOCATED JUST BELOW THE

Fuel oil for these engines is a gas oil ranging from 34 to 36 gravity. The water for cooling the cylinders is taken from the city mains and after having served its purpose at the engines it is piped over to a tank in the freezing room where it is used as a dip bath to free the ice blocks from the cans. When the plant was motor driven warm water for this purpose was obtained from a water trough which was placed around a horizontal run of the compressor discharge line. This trough is still used as an initial step in cooling and condensing the ammonia gas.

Fuel oil storage for the engines is arranged for by a 12,500-gal. tank which is located so that the oil will flow by gravity to the engines.

Electric current from the alternator driven by the 100-hp. engine, furnishes the power to drive the third compressor which is an 8 by 12-in. Wolf machine. This machine is driven by a rubber belt from a 15-hp. General

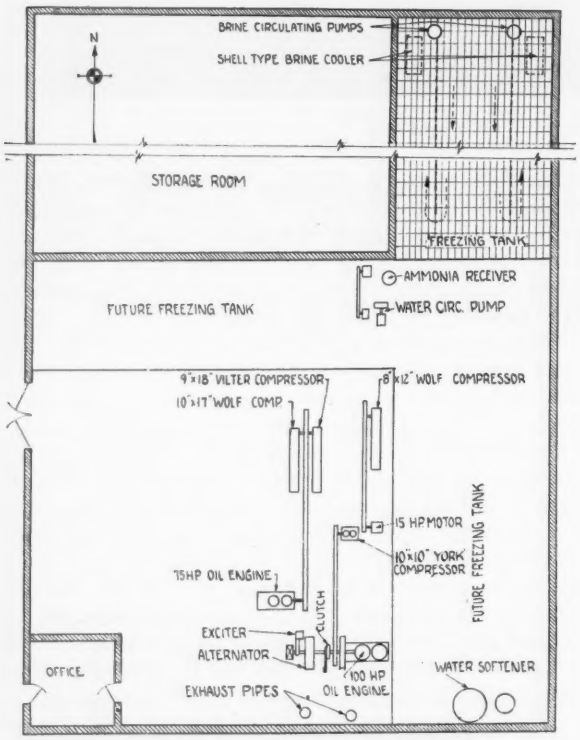


FIG. 5. SKETCH SHOWING THE FLOOR PLAN OF THE PLANT

Electric Co. motor which is rated at 220 a., 3 phase, 60 cycles, 1160 r.p.m. and 40 deg. rise in temperature in continuous service. This motor is actually pulling a 24-hp. load and it is standing up well without heating dangerously. With the York and the motor-driven 8 by 12-in. Wolf machine in operation this plant is averaging 42 T. of ice per 24 hr. and is also carrying the storage room which measures 103 ft. long by 87 ft. wide by 12 ft. high.

Two Condensers Have Been Installed

Compressed ammonia gas is carried through the roof and then through a horizontal run of pipe which runs through the trough already referred to. It is then led directly to the condensers which are of single pipe construction but differ in the manner in which the gas is passed through them. The one condenser consists of 4 stands of 2 in. pipe, 24 pipes high. The gas enters at the top and passes downward in its pass through the condenser. In this way the coolest water comes in contact with hottest gas.

In the other condenser the gas enters from a manifold the 16 pipes in the first stand, passes back and returns forward through the second stand. There are 8 stands, each succeeding one being placed a little lower than the one just ahead of it so that the last stand is about 12 in. lower than the first. This allows the condensed ammonia to drain from the coils.

Condensing water is taken from a tank by a motor-driven Goulds Mfg. Co. pump which is rated at 300 gal. per min. against a 70-ft. head. This water is discharged through ten 2-in. spray nozzles located in a cooling tower which is over the condensers. The condensers are located about 10 ft. above the roof of the building. The water having passed over the condensers it drains back in the tank already referred to. Make up water is taken from the city mains.

Direct expansion takes place in the storage room coils. The gas is then led to two shell type coolers in the freezing room. The brine is circulated by means of two York vertical agitators. At the present time 756 cans are installed. Each can is of 400 lb. capacity making the capacity of the present freezing room about 75 T. per 24 hr. based on a 48-hr. freezing period. When not operating at full capacity the freezing time is about 60 hr. with 20 deg. F. brine. At full rating the brine is kept at 16 deg. F. The temperature of the storage room is maintained at about 29 deg. F.

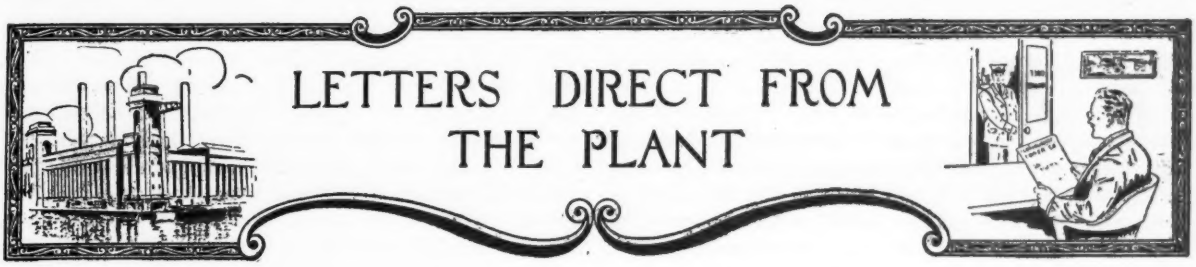
Air for agitation is supplied by a 7½-hp. motor-driven blower. The cans are hoisted two at a time by means of a Euclid electric hoist which is suspended from a trolley on a traveling I beam. Raw water containing about 13 gr. per U. S. gal. is taken from the city water mains which are supplied with water from Lake Michigan. All the water used in ice making is treated with lime and alum in an International water softener which is rated at 150 T. per 24 hr. After the water has been treated and allowed to settle it is passed through a sand filter. The final hardness is 3 gr. per U. S. gal.

Classification of Pipe

Commercial steel pipe is divided into four weight classifications: standard, extra strong, double extra strong and large O. D. pipe. Standard, extra strong and double extra strong pipe is designated by its nominal internal diameter; standard pipe in sizes from ⅛ to 12 in.; extra strong and double extra strong pipe in sizes ⅛ to 8 in.

Random lengths of standard pipe are usually considered as being from 15 to 22 ft.; while a range of 12 to 22 ft. with 5 per cent, or less, of 6 to 12-ft. lengths constitute the commercial random lengths of extra strong and double extra strong pipe.

The external diameter of extra strong and double extra strong pipe is the same as that of standard pipe, and the internal diameter therefore is smaller. Above the 12-in. pipe is usually classed as "large O. D." and is designated by its actual outside diameter.



Spray Pond Equipment Installed Under Difficulties

On the occasion of a visit to a public utility plant in Indiana not long ago, I saw a spray pond in which the spray nozzles had been installed under rather unusual circumstances. This pond was not of the conventional form, two or three feet deep; it was an old stone quarry, 40 ft. deep.

Up until a few years ago, a small stream, on the banks of which the plant is located, had been able to supply all the cooling water required but as the plant grew, as plants are prone to do, the stream was not able to meet the demand and it became necessary to use a cooling pond.

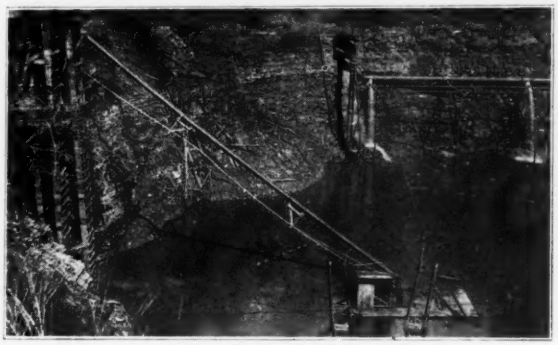


FIG. 1. THE PIT WAS EMPTIED BY MEANS OF A MOTOR-DRIVEN CENTRIFUGAL PUMP INSTALLED ON A RAFT

At first pond, which had a capacity of about forty million cubic feet, was sufficient to meet the requirements of the plant without any artificial cooling but as the load increased it was found necessary to provide spray nozzles.

To build a solid foundation capable of carrying the nozzles and the necessary supply and branch lines was no slight undertaking and in order to make the job as easy as possible, it was decided to drain the quarry. The bottom of the pit is considerably below the stream hence it was impossible to syphon the water out and a pump had to be used. Accordingly a motor-driven centrifugal pump was installed on a raft as shown in Fig. 1 and a flexible discharge connection was made to a ditch flowing into the stream.

For a short time after the emptying process was begun, the main circulating pumps were of assistance, drawing water from the pond and discharging to the stream but as the water gradually receded the suction lift became too great for efficient operation and the circulating system was changed over to take water from the creek. The suction head on the pump on the raft did not change, of course, although the discharge head did increase as the raft sank with the water level. After several days of pumping the water was practically all discharged and it was possible to go ahead with the erection of the scaffold. The vertical members, consisting of 50-ft. transmission

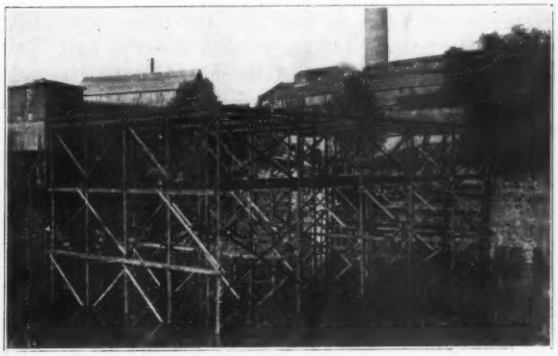


FIG. 2. THE PIT WAS ALLOWED TO FILL AFTER THE SUPPORTING STRUCTURE HAD BEEN COMPLETED

line poles, were erected and securely held in place with diagonal braces as shown in Fig. 2.

To prevent flotation of the structure the lower end of each pole was weighed down by casting a heavy block of concrete around the bottom. When all the work below

FIG. 3. OF THE TWO, THE STRUCTURE SHOWN IN THE FOREGROUND WAS THE LESS COSTLY

the normal water level was finished, the pit was allowed to fill up again. In the meantime a skeleton floor was laid across the top of the piles and the necessary nozzles and piping was placed.

Not much more than a year after this work had been completed, further increase in load on the station began to tax the cooling water system beyond its capacity, additional spray nozzles were found necessary and it was

decided to build another structure similar to the first. This time, however, another method of procedure was employed.

The pit was not drained as before. A large raft was constructed and on was mounted a gin pole. With this equipment, poles, that had been previously loaded with concrete at one end and that had had the lower end of a cross brace bolted in place, were lowered into position. When two adjacent poles had been lowered the upper end of the cross braces were made fast and so the structure was built up. When the scaffold was completed a skeleton floor was laid and the nozzles installed as before. Figure 3 shows the two structures; the one that was built with the pit flooded is in the foreground.

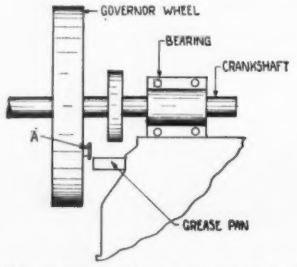
Although the actual cost of these two structures was practically the same as was also the time required for building the last one built was much easier to handle and further it required no curtailment of station capacity while it was being erected, owing to lack of circulating water. All things considered the net cost was considerably less in the second case. When, therefore, in the future it becomes necessary to install additional nozzles, the second method will be used.

Chicago, Ill. TOM BAKER.

Cause of Noise in Engine

SOME TIME ago when starting my engine one morning I noticed a clicking noise in the eccentric. Shutting down again I examined every part of the eccentric but found nothing wrong. The engine was started again with the same noise as before. After the engine was up to speed, however, the noise disappeared but reappeared when shutting down at noon. This was a puzzle to me.

This engine is of the high-speed automatic type and that night after shutting down I examined every part of



BENT GREASE PAN IS CAUSE OF NOISE IN ENGINE

the eccentric, also the governor, but still could find nothing wrong. Then I thought that perhaps some of the pins and bearings in the governor were worn badly or were dry, so decided to take the entire governor apart the next Sunday. When about to do this, however, I discovered the cause of my trouble accidentally.

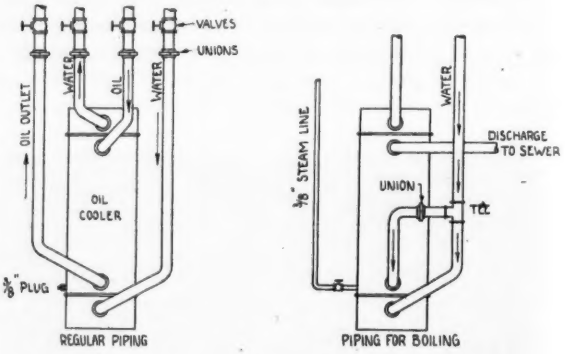
The engine bearings are lubricated by the splash system, while the eccentric is lubricated by an automatic grease cup. To catch the drippings of grease from the eccentric a sheet iron pan was located under the eccentric and fastened to the engine frame as shown in the illustration at A. When I was about to take the governor apart, I noticed that one of the bearing pins from the governor which projects a little beyond the governor wheel, would strike the grease pan at each revolution of the engine while it was running slow. When the engine was up to speed, however, this bearing pin in the governor would be in a different location, hence the noise would disappear. The reason the governor pin was striking the pan was due to the fact that the night before I noticed the noise I had the grease pan cleaned and in doing this the man had used too much hand pressure, thereby bending the pan into such shape that it would come in contact with the governor pin. After the pan was bent in to its proper shape again, the noise was eliminated.

This shows that at times we look in the wrong place for the reason of our troubles.

Milwaukee, Wis. H. A. JAHNKE.

Cleaning Oil Cooler

IN OUR plant we were troubled with unsatisfactory cleaning of our oil coolers. Even though we boil the bundle of tubes in an open tank with a strong solution of lye water and other cleaning compounds for a period of a week or 10 days, we do not get the desired result.



ARRANGEMENT OF OIL COOLER PIPING FOR CLEANING

As shown in the accompanying drawing of this type of oil cooler, by using a little extra piping and without removing the bundle of tubes from the outside casing, a thorough boiling for about 3 hr. without any cleaning compounds whatever being used will result in a most satisfactory job.

After connecting pipes as at B, let enough water in valve A so that a small stream can be seen coming out of discharge pipe during the boiling period, then turn on the boiling steam through the ⅜-in. line and boil for about 3 hr.

After boiling for the allotted time, pull out the bundle of tubes and blow them with an air or steam hose to remove burnt oil and other impurities.

While the boiling is taking place the water tubes are also filled, hence there is no danger of distortion of the tubes.

This method has not only proved economical but it can also be done in a few hours where time is an important consideration.

Canon City, Colo. W. J. HASTINGS.

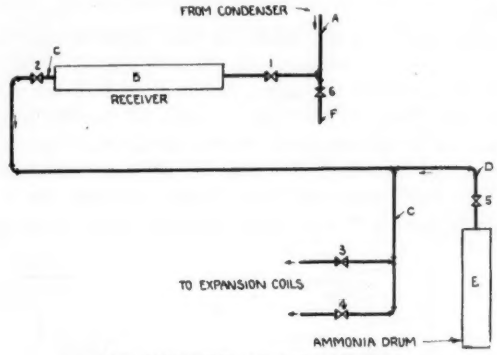
Charging Ammonia Systems

VARIOUS articles on charging ammonia systems, appearing in several of the late issues of Power Plant Engineering, have been read by this writer and R. A. Cultra's remarks in the July 15 number, page 772 evoke the following remarks: The main point which started this dis-

cussion I believe is: When recharging will ammonia flow from the system back to the drum from which it was taken? I would answer it all depends upon how the connections through which the ammonia is taken from the drum are made to the system, the location of the valves and how they are manipulated.

Before explaining the accompanying sketch of a small refrigerating plant which is under my care at the present time, I wish to correct some statements, relative to pressures in ammonia systems, which my experience teaches are in error. One statement is that the low pressure seldom exceeds 10 to 15 lb.

When a refrigerating system is working at capacity the usual low pressure is between 25 and 35 lb. If it is



ARRANGEMENT OF THE SYSTEM

much less than 25 lb. the gage may be wrong, the machine not working properly, or the load is much lower than the capacity of the system.

When the load is light the pressure on the low side may get as low as 5 lb. Under such conditions, however, the efficiency of the plant is extremely low. When the entire system is in proper working order the compression pressure will range from 180 to 210 lb. In view of these facts it must necessarily follow that in order to take ammonia from the drum it must be connected to the low pressure side and in such a way that the liquid will be taken from the drum, passed through the expansion coils, then through the compressor and the condenser to the receiver. The sketch already referred to indicates the hook up of the portion of the system being discussed. A is the pipe line from the condenser to the receiver, it being provided with an extension for removing the ammonia from the entire system when required.

C is the ammonia line from receiver B to the expansion coils. D is an extension to C and to this line the ammonia drum is connected when recharging is needed. The numerals 1 to 6 inclusive indicate valves.

During normal operation valves 5 and 6 are closed at all times. Valves 1 and 2 are wide open and the flow of the ammonia to the coils is regulated by valves 3 and 4. When recharging, the drum is connected to D, with the closed end raised about 6 in. Valve 2 is closed. Valve 5 is opened wide and the stop cock on the drum is opened slowly. If all connections between the drum and the system are tight the valve is given full opening. The flow of ammonia to the system is controlled by valves 3 and 4 which are adjusted until the low pressure gage shows about 30 lb.

Our equipment is old and for various good reasons no gage glass was installed on the ammonia tank so we have to be guided somewhat by the compression gage in determining when to stop charging. When the stop cock on the drum is first opened frost will form on the connecting pipe D; however, when the cock is wide open the frost melts and the temperature of the pipe D will be about the same as that of the liquid ammonia flowing through it.

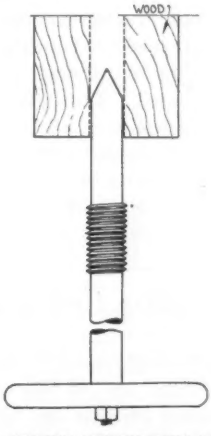
When the tank is empty frost will again form on pipe D, also on the under side of the drum at F and the low pressure gage will indicate a rapid fall in pressure. When this gage indicates a slight vacuum the stop cock on the drum and valve 5 are closed, valve 2 then being opened and normal operation restored. Should the system not require the entire contents of one drum, when the desired amount has been taken in, valve 5 is closed and valve 2 opened and operation may be continued as usual.

With this system of connecting the drum and the method of recharging just described, there is only one way that liquid ammonia can and will flow from the system back to the drum. Valves 3 and 4 are open only about one-fourth of a turn most of the time. Valve 2 is wide open. This leaves line C full of liquid ammonia. If the empty drum is still connected to the extension D and the stop cock and valve 5 are open, ammonia will flow back to the drum.

New York, N. Y. A. K. VRADENBURGH.

Repair for Water Gage Cock

WHEN THE threads in the body of a water gage cock become so worn that the spindle jumps its threads, the cock can be made as serviceable as ever by moving the spindle to a new location in the valve body. This is done by lengthening the spindle from the seat end which places the threads on the spindle at the top part of the body threads where there has been little if any wear.



MOLD FOR ADDING EXTENSION TO SPINDLE

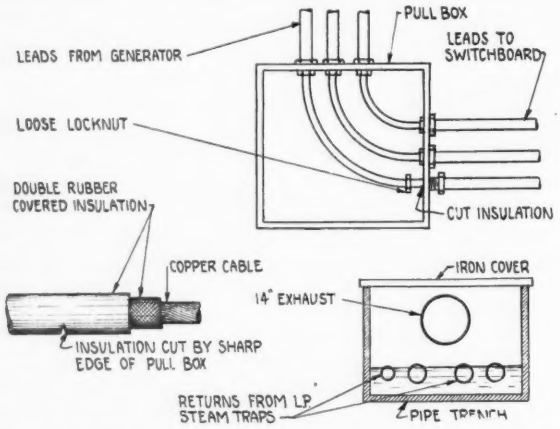
Bore a hole in a piece of dry wood, the hole being a tight fit for the spindle end, tin the tapered end of the spindle and while it is hot place it in the hole in the wood as shown and pour melted babbit in the hole.

It is now a simple matter to cut the babbit extension to the desired length with a hack saw and to file it to the right taper. The same method can be used, of course, with a flat seat. If the seat in the body of the valve is grooved it can be refaced by using a tapered or flat drill according to its shape.

Toronto, Ont. J. E. NOBLE.

Locating a Ground

To AVOID certain obstacles, the leads from a 150-kw. generator were run to the switchboard through a room adjoining the engine-room. A pull-box had been placed on the wall, about 4 ft. above a pipe trench, carrying a 14-in. exhaust pipe and several small return pipes from low pressure traps. One day, difficulty was experienced in keeping the circuit-breaker for this machine closed. The ground detector showed a heavy ground on this generator. An investigation of the trouble led to the pull-box. On removing the cover it was found that a lock-nut had worked off



the end of the conduit pipe and the pipe had pulled out of the box, as shown in the accompanying sketch, allowing the cable to rest on the thin metal of the box. Vibration, which had caused the pipe to work loose, had also worn the insulation on the cable until it was nearly cut through to the copper at this point. An extremely high tide had backed water up in the trench until the hot pipes were submerged. The steam arising through the cracks in the trench cover had dampened the insulation on the cable at the cut thereby causing the ground. The pipe and nut were replaced and secured. The damaged insulation was repaired with tape and shellac. All the exposed insulation in the box was given a good coat of asphaltum paint. Each cable was then sewed up in tarred canvas and painted again and we had no more trouble from that source.

Utica, N. Y. M. M. BROWN.

Unusual Ammonia Compressor Repair

SHUT-DOWNS in an ice plant are serious. Quick thinking and quick action on the part of the operator when a shut-down is impending are of the utmost importance. An unusual illustration of what can be done in an emergency came to my attention recently.

One evening at about 5:00 o'clock, an 80-T. ammonia compressor developed trouble. The unit was shut down and on taking the piston out the rings fell in pieces on the floor. Unfortunately the reserve rings had been used only a few days before and the new ones had not arrived. All shops where these rings could be made up were closed for the day and it was a case of the engineer doing something and doing it quickly or waiting until the next day.

He managed to procure an automobile engine flywheel, that had been junked. Out of the rim of this wheel he turned up the needed rings and had the engine back in service by midnight after an elapsed period of 7 hr.

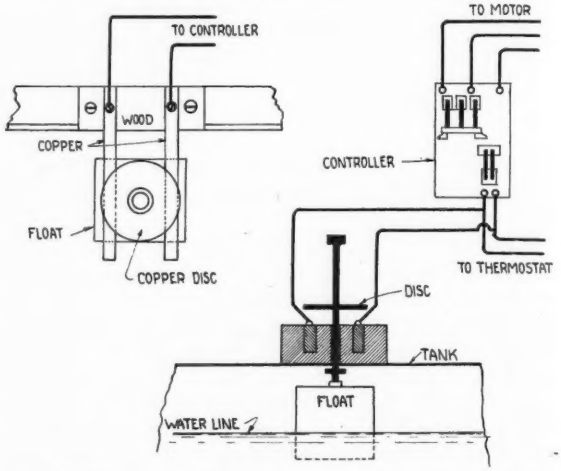
Had it not been for his resourcefulness it would have been a matter of a day or more before the unit would have been put back in service and the loss of capacity would have been exceedingly costly.

Arlington, N. J. GEO. C. WELLS.

Safety Stop For Cooling Motor

WE HAVE in our plant a small SO_2 refrigerating machine to keep the drinking water at a lower temperature than prevails in the city mains during hot weather. This machine is convenient where there is no skilled labor employed since it has all of the refrigerating mechanism confined. One end of the apparatus is placed in a tank called the condenser tank and the other in the liquid to be cooled.

Water supply to the condenser tank must be such that it will not reach a temperature of more than 110 deg. F. and it is customary to place a ball float to keep the water at the right level. If the water is shut off for any reason, the motion of the machine when running will throw the water out at the overflow so that it will not come in contact with the sphere and thus it will heat and the compressor pistons will bind and cause the machine to stop.



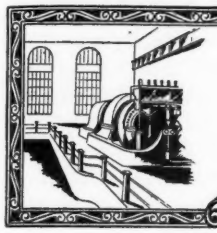
FLOAT ACTUATES AUTOMATIC STOP ON ICE MACHINE MOTOR

The machine is controlled by a thermostat in the drinking fountains. When the temperature has reached the proper point, contact is made through a special controller, and the motor is automatically brought up to speed.

To stop the machine when the cooling water supply fails, a block, which may be either wood or fiber, is bolted to the angle iron rim of the tank. In the block two slots are cut and two copper bars are fitted. The copper float has a rod running through a guide fastened to the side of the tank and to this rod, at the proper height is attached a copper disk large enough to span both copper bars.

As long as the water is at the proper height, the disc is in the position shown but if the water gets low enough it will be drawn down by the float and will lie across the copper bars, short-circuiting the current going to the magnet which holds the contactor up on the controller and causing it to open the circuit and stop the motor. If, after the water had failed, it should be turned on again, the float would rise and allow the machine to start again.

East Dedham, Mass. G. H. KIMBALL.



QUESTIONS AND ANSWERS

Braces Required for Staying Tube Sheets

ON PAGE 719 of the July 1 issue, J. C. B. asks for a method for determining the number and size of stays required to support the upper section of the tube sheet of his boiler.

First, it is necessary to find the area of the segment to be braced. The circle, of which the segment is a part, is 36 in. in diameter, and the area is 1017.9 sq. in. The area of the semi-circle is then 508.95 sq. in.

Next, consider the area between the base of the segment and the diameter of the circle, as that of a rectangular figure whose dimensions are $8 \times 35 = 280$ sq. in., as

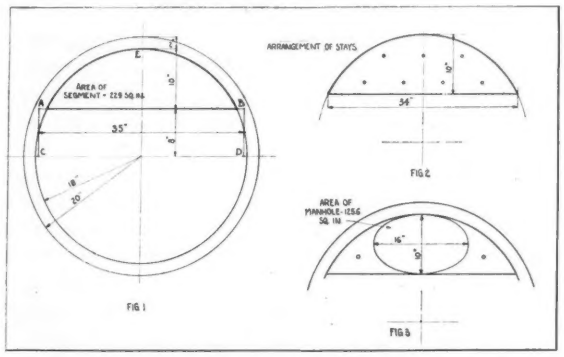


FIG. 1. AREA TO BE STAYED IN BACK TUBE SHEET IS 229 SQ. IN.

FIG. 2. SEVEN 1⅜-IN. DIAGONAL STAYS SHOULD BE USED IN THE BACK SHEET

FIG. 3. TWO 1⅝-IN. DIAGONAL STAYS ARE REQUIRED IN THE FRONT SHEET

shown in the sketch, Fig. 1. From the area of the semi-circle subtract the area of the assumed rectangular figure, 508.9 — 280 = 229 sq. in. in round numbers, area of the segment in question. This is correct within less than 1 per cent and is probably the simplest method to use.

As the steam pressure carried is 200 lb. per sq. in., the total pressure on the segment, to be supported by stays, is $200 \times 229 = 45{,}800$ lb. Assume that 6000 lb. per sq. in. of net section is allowed for the stays, and that the stays are to be placed on 6-in. centers to support an area of $6 \times 6 = 36$ sq. in.

Then, $229 \div 36 = 6 +$, or say 7 stays will be required. The size of the stays is found from the equation, $A = 36 \times 200 \div 6000 = 1.2$ sq. in. for direct stays. The diameter will be, $\sqrt{1.2 \div 0.7854} = 1\frac{1}{4}$ in. Diagonal stays would ordinarily be used, and they must be larger in diameter than direct stays for the same work. While no dimensions are given to work with, the equivalent diameter of the diagonal stays will probably be 1⅜ in., as the nearest commercial size that would be used.

The arrangement and location of the stays would probably be similar that shown in Fig. 2. However, they may be arranged in circular rows instead.

With regard to the other head in which there is a 10 by 16-in. manhole, reinforced by flanging, we subtract the area of the opening from the area of the segment. The area of the opening is: $10 \times 16 \times 0.7854 = 125.6$ sq. in. and the area to be stayed is 229 — 125.6 = 103.4 or say 104 sq. in. Evidently, there is room for one brace only at each side. Then, $104 \div 20 = 52$ sq. in. is the area to be supported by each brace.

As the stays are assumed to be allowed but 6000 lb. per sq. in., then, $52 \times 200 \div 6000 = 1.73$ sq. in., the area of stays required. This gives 1½-in. diameter for direct stays, and an equivalent diameter of 1⅝ in. for diagonal stays. The arrangement would be as shown in Fig. 3.

Brooklyn, N. Y. CHARLES J. MASON.

EDITOR'S NOTE: The method given by the author for finding the area of the segment is correct within less than 1 per cent when the rise is large as compared with the radius. When the rise is comparatively small, the error may be considerable. A more accurate, simpler and perhaps a more common method of finding the area to be stayed is that used in the A. S. M. E. boiler code,

$$A = \frac{4\ (H-d-2)^2}{3} \qquad \frac{2\ (R-d)}{(H-d-2)} - 0.608$$

where H is the distance from the tubes to the shell, d is the width of the annular strip adjacent to the shell which requires no staying, 2 is the width of a strip above the tubes which does not require staying and R is radius of the shell.

Substituting the figures given and solving this equation, it is found that A = 229.47 sq. in.

Air Chamber Capacity for Pump

REFERRING TO Mr. Riecke's question in the July 15 issue regarding air chambers for pumps, I think the ones he has now are of ample size but poorly placed and that, if the piping were rearranged, they would work satisfactorily. If new air chambers were to be installed, I would recommend making them of the same size as the pipe in which they are used but do not believe the slight advantage would repay the expense of scrapping those now in use.

The purpose of an air chamber is to absorb part of the energy of the flow of water at the point of highest velocity of the surge and return it again when the velocity in the pipe has dropped too far below the average, thus evening the floor curve by cutttng off the tops of the hills and filling in the valleys. Since the impact effect is dependent on the change of momentum, which again is pro-

portioned to the difference of the squares of the velocities, it will be seen that if, without the air chamber the flow stops at the end of the stroke and rises to 10 ft. per sec. at the highest point and that with the air chamber, this is reduced only 20 per cent to 8 ft. per sec. and correspondingly increased at the stop point to 2 ft. per sec., the relative momentum will be $10^2 - 0^2 = 100$ and $8^2 - 2^2 = 60$ or that this will have practically cut the momentum in half. From this it will be seen that it is important both from the point of reducing the high velocity and having the energy stored by the compression of air in the air chamber available to create the low velocity, to have this process as efficient as possible. This means that the stream of water should be directed against the body of air in the chamber either without a change of direction of the pipe, or, if this is impossible, with as easy a bend as possible and without change of area, since, particularly if the air chamber be made larger than the pipe, there will be a loss due to eddying when the velocity of the water entering is reduced to correspond with the larger area. If on the other hand the air chamber is made smaller than the pipe, this loss due to change of area will not occur on inflow of water to the air chamber but will occur when it is fed out at the end of stroke, thus reducing the velocity obtainable at such times.

In Mr. Riecke's arrangement the suction air chamber would be much more effective if rearranged, with the suction line running through the run of the tee in a direct line to the ell and air chamber so that the surplus energy of the water column in the suction line as the piston slows down, will be guided directly into the air chamber where it can be used, instead of, as at present, being largely dissipated in eddies at the tee.

It is also possible that the discharge air chamber would be improved by lengthening the nipple below the tee so as to obtain a more accurately directed flow into the air chamber.

One essential to the proper working of an air chamber is that it shall contain air and, as air is much more soluble in water at feed line pressures than at atmospheric pressure, this usually means periodic refilling. If compressed air at more than feed line pressure is available, this is easy, but where only moderate pressures or none at all is available it is not so good. If air at, say, 90 lb. is available, it may be piped into the air chamber and the pressure partly reduced while it is being filled. If no air pressure is available the pump and part of the line may be emptied and the air trapped there compressed back into the air chamber by admitting water under city or tank pressure. An auxiliary tank may be installed which, by alternately filling with air and compressing this by the water at pump pressure into the air chamber, will keep up the supply. Quite often an air chamber is blamed for functioning improperly when it has not been kept full of air.

As a rule, suction air chambers should be comparatively high as they are likely to be subjected to greater proportionate differences of absolute pressure, particularly when pumping at variable rates through long suction lines. If the pressure is likely to fall low enough to allow air to come over into the pump and cause air binding, the pump capacity may be considerably reduced.

New Haven, Conn. H. D. Fisher.

Is the Governor Over Sensitive?

Replying to W. B. C.'s question concerning the erratic action of his governor which appeared on page 719 of the July 1 issue, I think the governor is not over sensitive but that the load on the engine is too light for the boiler pressure carried. In my experience, I do not know of any engine which runs well with a cutoff of less than 1/5 stroke, which he states is the case with the small unit, while the large unit cuts off at 1/7 stroke.

Full boiler pressure acts on the piston during that short part of the stroke before cutoff occurs and gives the heavy flywheel a sort of sledge hammer blow, which causes the governor to rise to its full speed position at the time the point of cutoff is reached. Then the load resistance causes the speed of the flywheel to decrease gradually during the remaining part of the stroke, which causes the governor to drop to its lowest position at the beginning of the next stroke.

To remedy this condition put enough load on the engine to give a later cutoff or decrease the boiler pressure enough to increase the length of cutoff to 1/5 or ¼ stroke.

Cambridge, Mass. R. A. Cultra.

Turbine Wheel Velocity

In an impulse type steam turbine, if the nozzle makes an angle of 20 deg. with the plane of rotation of the wheel, what should be the peripheral velocity of the blades, for maximum efficiency, if the jet velocity is 4000 ft. per sec.?

F. G. T.

A. For the ordinary impulse turbine, the peripheral speed, C, of the vanes for best efficiency is made equal to the product of the jet velocity, V, and ½ the cosine of the angle, A, that the jet makes with the plane of the wheel. As this angle, A, is 20 deg., ½ cos. A = 0.47, and as V = 4000 ft. per sec., C = 0.47 × 4000 = 1880 ft. per sec.

This velocity is too high for safety. Ordinarily, it should not exceed 1200 ft. per sec. With a peripheral speed of 1200 ft. per sec. the efficiency:

$$E = 4\{C \div V\}\{\text{Cos. A} - (C \div V)\}$$
$$= 4 \times \{1200 \div 4000\} \times \{0.9397 - (1200 \div 4000)\}$$
$$= 76.7 \text{ per cent}$$

It would seem that the velocity you have specified, 4000 ft. per sec., is rather high. If the peripheral speed is 1200 ft. per sec. and the angle of the jet 20 deg., the maximum efficiency would be obtained with a jet velocity of 1200 ÷ .47 = 2550 ft. per sec.

What Causes the Hook?

In reply to the question by J. L. concerning certain defects in his engine as shown by his indicator card, on page 618 of the issue of June 1, I would say that the hook on his admission lines of his low pressure diagrams is probably due to the fact that the valves do not open soon enough. By the time they have opened the piston has already moved a considerable distance from the dead center position and as a consequence there has been a slight pressure reduction in the cylinder. As the pressure is only 10 lb. these valves must open sooner than would be necessary with a higher pressure.

New Haven, Conn. W. H. Wakeman.

Efficiency of Butt Strap and Ligament

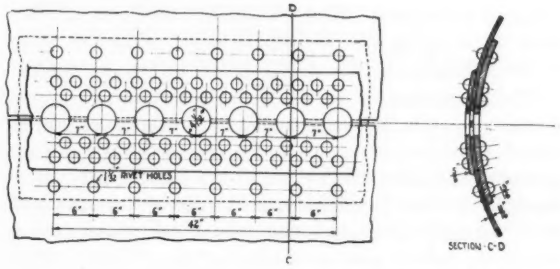
WHAT IS the net efficiency of the triple riveted double butt-strapped seam and circulating tube connection shown in the accompanying sketch? How is it calculated?

W. E. S.

A. Using the dimensions given and assuming certain other quantities, we have the following:

t, thickness of the shell = $\frac{11}{16}$ in.
t_1, thickness of outer strap = $\frac{5}{8}$ in.
t_2, thickness of inner strap = $\frac{13}{16}$ in.
T_s, tensile strength of the sheets = 55,000 lb.
S_s, shearing strength of the rivets = 44,000 lb.
C_s, compression strength of the plate = 70,000 lb.
d_1, diameter of tube hole = $4\frac{1}{32}$ in.
d_2, diameter of rivet hole = $1\frac{1}{32}$ in.
P, tube pitch = 7 in.
u, pitch of outer row of rivets = 6 in.
N_1, number of tube pitches considered = 6
N_2, number of rivet pitches considered = 7

The unit section considered will contain 6 tube pitches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Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Dealing in Futures

By far the most important development in the grain trade in many years, is the grain elevator merger and sale recently made public.

Physical properties of five of the country's largest grain elevator operators together with over 1000 country elevators are to be taken over and operated by farm organizations headed by the American Farm Bureau Federation, is the plan. The immediate cash transaction will involve ten or twelve millions of dollars, the ultimate total to be paid by the farmers running in excess of fifty millions.

The idea behind the project seems to be that through direct producer operation the profits that have hitherto accrued the elevator owners will revert to the farmers.

Farmer's cooperative grain elevators are not new. The town, located in a grain producing community, that does not support one is the exception. They have, however, always been local in interest and small in capital. So few of these small elevators have been successful that those yielding a profit to their owners are a novelty. The success of the enormous $50,000,000 merger can only be told by time.

If the management of the big undertaking is put in the hands of experienced, capable, non-partisan business men, *and left there,* it may be a success. If the control is maintained by the farmers themselves or is given over to professional organizers, failure seems inevitable. In such an event, you and I, all of us—the Government—will hold the bag and foot the bill. In the event of ultimate success, the farmers will be able to save the net profit of Armours, the Rosenbaums, the Schaffer Company and Davis, Merrill & Noland. This net profit, when added together, then divided among the two million odd farmers, may prove a surprisingly small sum.

Even in the event of eminent success, the farmers will have a long walk 'round Robin Hood's barn to gain their end.

Industry Needs Trained Executives

There are approximately 300,000 large and small manufacturing establishments in the United States. Reports from the Federal Government show that less than half of these companies ever make one cent of profit and that less than ten per cent of them know what their actual cost of production is.

Only recently the National Industrial Conference Board predicted in its report that there will be a shortage of between 200,000 and 300,000 trained industrial executives by the year 1930. This report further states that there will be less than 50,000 men who will have been trained by that time, to take over the management of industrial properties.

There are four distinct phases to manufacturing activity. They have to do with the control and coordination of men, methods, materials and equipment. Knowing the four elements that enter into manufacturing, what is being done in your organization to ground executives thoroughly in the fundamental principles of control and coordination? Obviously, if these reports are accurate (and such Government reports have the habit of being respected), something must be done—quickly.

Concomitant with gigantic corporations, according to industrial relations experts, is the lack of personal contact between managers and working personnel—employers and employes. The lack, they say, is the principal reason for all social evils and industrial discontent. Yet the fact remains that large corporations are universally more successful than their smaller brothers and the employes of large corporations enjoy, in most cases, more benefits than do the employes of the small shop.

As we see it, the benefits accruing the working personnel of corporations is due largely to the better management the big enterprise enjoys. The responsibility of management of large interests entails knowledge of a wide range of principles. This knowledge, resulting only from superior training and ability, is reflected in the welfare of the employes.

To be an asset to an industrial enterprise, the general manager should be well-grounded in economics, finance, advertising, management systems and methods, sales management and sales methods, cost-accounting practice and production. He should have, also, a general acquaintance with the technology entering into his product, material handling, warehousing, and the analysis of raw materials. He should be schooled in industrial development from the historical side, should be thoroughly informed regarding manufacturing site selection and should keep abreast of current developments and improvements made by his competitors.

We know several large organizations, and many small ones, that would be seriously handicapped by the prolonged absence of the president or manager. That is not a healthy condition. Such a circumstance does not make for the continued or assured prosperity of the individual concerns. If your organization is in that condition, it is high time to begin the training of your future management.

In Fairness to Our Freight Carriers

Samuel O. Dunn, of the Railway Age, has set forth the following:

Since 1914, the average freight rates have risen	51½	per cent
Since 1914, the average wholesale prices	53	" "
Since 1914, the average cost of living	65	" "
Since 1914, the average earnings of railway employes	95	" "
Since 1914, the average hourly earnings of railway employes	139	" "

The discrepancy between the percentages of increase in hourly and annual earnings is ascribed to the fewer hours which men are now working.

It is well to remember the above percentages when freight rates are attacked and bills are introduced in Congress to effect their drastic reduction.

Where Saturation Point Is Variable

There is one motor vehicle for every seven persons in the United States. Registrations totaled 15,523,898 on July 1, 1924. This is an increase of 19 per cent over July 1, 1923.

In the face of automobile and truck increases, it is interesting to know that the motorcycle registrations have steadily decreased since 1919. On January 1, 1920, 240,-090 motorcycles were registered in the United States. Today the registration stands at 126,386,—a decline of almost 50 per cent in less than five years.

In 1895 motor vehicle registration totaled about 300. In twenty years, or 1915, our usage of motor vehicles had increased to about 2,500,000. It has only been during the past ten years that we have added the extra thirteen millions.

As far back as 1918 and 1920 we heard people say, "We have reached the saturation point in automobiles. We cannot accommodate any more." Knowing this, we hesitate to follow suit with such a statement. Indeed, we would not, for we believe that the car registration figure will shortly reach 20,000,000.

Trade Journals and Trips Abroad

In the regiment with which the writer was identified during the war was a young man of twenty-four—a farmer from Strawberry Point, Iowa.

That chap hated war. He hated everything military. He wanted to go home. The result of his mental state was deplorable, as you will see in another paragraph or two.

In our war service we traveled through beautiful Ontario, through the Catskills, down the historic Hudson River, edged with unexcelled beauty. We floated out past the Statue of Liberty, who was just then waving to us a "God Speed" with her torch. After fourteen interesting days on the water there followed in rapid succession Brest, La Mans, Tours, Blois, Paris, Chateau Thierry, Soissons, St. Mihiel, Verdun, Coblenze and the Rhine,—Paris again, Bordeaux, Newport News—and Home. Eighteen months of interesting travel.

While enroute to our demobilization camp we stopped for two hours in a railroad yard in Chicago. The chap of whom I have spoken suddenly rose from his seat, looked out of the car window, and said: "I wonder how long we will be here in Chicago—? Gee! I'd like to get off. You know—I've always wanted to see Chicago."

After a year and a half of travel that boy had just come to the realization that he *might* be able to *see* something on the trip. As for the writer, while he wouldn't go through the thing again for $10,000, he wouldn't sell his experiences and memories for $100,000.

Readers of trade journals are like that. The value of the trade or technical publication depends entirely upon the reader. Two men will read the same article in a journal. One immediately sees its application to his own work and applies the information to advantage in his own plant, store or office. The other is unable to see any similarity between his work and that described in the article, and therefore reaps no benefit.

The one who recognizes similarity between the article and his work is very often reminded of a working experience in the past which had proved profitable to him, and he writes the editor about it. In this way he extends and perpetuates the value of his experience. By so doing he aids his industry. The other fails to contribute valuable items of profit or experience, thus making it necessary for another to rediscover, oft-times at considerable expense and worry, what was already known.

Trade journals, like trips abroad, are what you make them.

Radio to Maintain Employer-Employe Contact

Sir Henry Thornton, President of the Canadian National Railways (a 22,000 mile system), in speaking before a club in New York City some time ago, detailed an interesting proposal.

It is his idea that officials and executives of large companies are not in close enough contact with their employes. Just how he intends more closely to knit his own relations with the thousands of employes, scattered over an area nearly as large as the United States, can best be told by letting Sir Thornton speak. We quote:

"We intend to establish a chain of broadcasting stations from the Atlantic to the Pacific at such intervals as will enable headquarters to keep in constant touch with the whole property. Furthermore, we propose to place at the disposal of our employes radio sets for a moderate price. These can be bought outright or at the rate of one or two dollars a month.

"The result will be that in a comparatively short time most of our men will have equipped themselves with wireless sets and we propose, as fast as circumstances require, to talk to our men in the evenings at their own homes. I propose, myself, as president of the company, to speak at least once a week to our men."

To our knowledge, no more powerful instrument for good, or for evil, has yet been devised than the radio.

Facts vs. Fancies

Among the American sources of misinformation the barber shop is the greatest. Barring the long-suffering wife, the amiable and agreeable barber is the one who can, with the most grace, swallow home-spun statistics and otherwise unknown facts.

While enduring our fortnightly haircut the other day, the customer in the next chair was waxing eloquent regarding advertising. Evidently he knew all about it. According to him the "billions" spent on "advertising" was the sole reason for the high cost of everything from radio to rat poison. He wanted a law passed to prohibit advertising. (Invariably such fellows want "a law passed.")

We didn't start an argument. But we couldn't help thinking of the camera now selling for $10 that formerly cost $25—and the present camera a better instrument.

Twenty years ago it cost a canner 20 per cent to sell 500,000 cans of a famous brand of soup. Now it costs him 5 per cent to sell 18,000,000 cans weekly—and with an increase in both quantity and quality. Without advertising there could have been no such demand.

When the war closed the government had on hand an enormous stock of surplus material. The government had no retailers, no salesmen, no method of distribution. Yet this material was sold for nearly three billions of dollars, entirely through advertising. Seventy per cent of this advertising was placed in trade, technical and industrial journals.

EDITORIAL COMMENT

Illumination in the Power Plant

Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the past few years, numerous investigators studying the cause of accidents have found that the accident rate in plants with poor lighting is higher than in similar plants which are well illuminated. Factories which have installed improved lighting systems have experienced reductions in their accidents which are extremely gratifying.

Of even greater importance, poor lighting impairs vision. Because diminution of eyesight from this cause is gradual, it may take the individual years to become aware of it. This, however, makes it all the more important to guard against the insidious effects of dim illumination, of glaring light sources shining in the eyes, of flickering light, of sharp shadows and of glare reflected from polished parts of the work.

While these are only two of a number of deleterious effects of poor lighting they are the principal ones and in themselves are sufficient reason for installing nothing but absolutely the best in lighting systems. The many advantages of good lighting are being more and more appreciated in industrial plants and much has been accomplished during late years in improving lighting systems.

Strange to say, however, illumination in the power plant, the place in which light is manufactured, has not kept pace with lighting progress and the average industrial power plant is not illuminated any better today than it was fifteen years ago.

The advantages accruing from good lighting are just as numerous and of just as much value when applied in the power plant as when applied in the industrial plant. Good illumination in the power plant promotes cleanliness and efficiency. It reduces accidents, and due to better maintenance given the equipment, results in lengthening the life of such equipment.

It is obvious that if a room is well lighted and where parts of installed apparatus are clearly visible, attendants will take more pains to keep such apparatus clean and in good condition than they would if the room was dark and where deep shadows cover up accumulations of dirt and oil.

Good illumination, however, does not necessarily imply high luminous intensity. A good lighting system calls for the fulfillment of three requirements, light of a suitable quality, light from the proper direction and light of the correct intensity.

Take for example the case of the control room of an electric power station, where it is necessary to supply adequate illumination to a large number of glass covered instruments mounted, usually, on black panels. To illuminate such a room correctly, requires not only a careful study of the various pieces of equipment and the grouping of the component parts, but also a careful analysis of the operator's duties and his methods of performing them. He must be able to read the instruments from a suitable distance without straining his eyes; his normal course of action must not carry him within the range of unprotected sources of high intensity illumination; because of the close scrutiny he is required to give to the instruments his vision must not be fatigued by extreme contrasts in luminous intensity of surfaces. These are only a few of the many factors to be considered in planning the lighting system for a room of this type. Other divisions of the power plant present similar problems in illumination.

In an article on the subject of illumination in the power plant appearing in this issue, A. F. Loewe, of the lighting service department of the Edison Lamp Works, discusses some of the unusual phases of power house lighting.

Plant Design Should Be Based on Engineering Economics

Power plant design, including the choice of the various items of equipment which enter into the design, is not a simple problem. In fact, it grows more complex with each improvement in the different types of equipment which are offered the prospective buyer. Quite naturally the engineer in charge of laying out a new station, or the improvement of an old plant, desires to get the most for his money in life of equipment, reliability and over-all cost of operation.

In considering the plant design problem, with all its complexities, no safer guide can be found than that summed up in the expression "engineering economics." It should be the slogan of the buyer. A slogan based on unprejudiced reasoning and on a complete analysis of all the factors involved. It means that the initial cost and the fixed charges must be balanced against the increased savings or the added reliability.

Designing and buying on a basis of engineering economics means that glib salesmanship on the part of the seller must be taken for what it is worth; that the apparatus must be judged on its merits and on the merits of the organization behind its production.

Keep the House Clean

Many volumes have been written on how to make a favorable first impression, as a salesman, as a job hunter, as a politician, as a business man, as a professional man endeavoring to build up a clientele. In every walk of life the first impression made upon future associates will make further progress either easy or difficult. It is only after one has acquired an intimate acquaintance with a man that you have anything more than appearances by which to judge his character. Notwithstanding this, the expert will not frequently go far wrong in his first impressions, for certain defects of character are almost invariably impressed in the mannerisms and speech of the individual.

As the workshop of engineers, the power plant makes an impression upon those who visit it, either favorable or unfavorable to the employes and owners. Nobody would look upon a purely show case plant with favor any more

than he would admire the character of the scrupulously dressed dude, nevertheless the power plant that is kept clean and neat as a pin will impress the visitor with the idea that other details of the work about the plant are looked after with equal care.

Too many engineers are of the opinion that it does not pay to make a show. If that were the entire object, the cost would be too great. The fact is, however, a poorly operated plant is extremely difficult to keep clean. Coal strewn on the boiler room floor and tracked over the entire plant, leaky boiler setting and breechings that emit soot to settle on all interior surfaces, leaky joints in steam and water piping, oil dripping from bearings or thrown from shafting are among the elements which cause a plant to become dingy and repulsive with dirt; at the same time they lower the economy of the plant to a marked degree. Thus, by bringing the economy of the plant to the top notch, the work of keeping things clean is greatly reduced. Remove the cause and the effect is eliminated.

Not only is a dirty plant caused by inefficient operation, but the effect of such an environment upon those who live in it is detrimental to economy; they are likely to give little attention to the many small details which go to make up economy.

The general character of the employes is undoubtedly reflected in the appearance of the plant. Cleanliness may be considered a nonessential element in the production of power, but a clean plant inefficiently operated is rare.

Labor Saving Equipment Helps Maintain Morale

It has become the order of the day to equip new power plants with labor saving equipment. Stokers, coal handling equipment and cranes are now put into small plants as well as in those of larger size. Why is it that in so many cases labor saving appliances and equipment have not been installed in those plants which were built a few years ago?

Many engineers consider that the installation of instruments, with the attendant economies resulting from their use, puts their plants upon a basis which is consistent with modern operation. Is this true? It is, in so far as fuel consumption is concerned but this one step does not affect other power plant costs and management problems except in that the operators will have less coal and ash to handle, which is a natural result to be expected from better fuel economy.

Wide awake operators do not stop at fuel economy alone but go further by a careful study of labor saving equipment, by making great efforts to reduce the number of injuries over a given period of time and to improve the morale of the employes. The installation of labor saving equipment opens the way to a reduction of the number of men on the job; it often reduces the labor turn over and assures a plant of obtaining and keeping a more intelligent type of men on the job. Cases are on record where the installation of an electric hoist to replace a hand operated chain block has greatly improved the attitude of operators and practically eliminated the labor turn over problem which had previously been of serious consequence.

Every engineer can well afford to go over his plant and study operation not alone from the view point of saving heat units but also from the view point of the class of labor which he has been employing; why so many men have left his service during the last year; how lost days can be saved by the prevention of accidents and how men can be replaced and the work made more agreeable through the installation of labor saving equipment.

Keeping Mentally Fit

When we were of school age the law compelled us to attend school. This enforced education was irksome to many of us but no man who is compelled to make his own living regrets in after years the time he was kept in school by a stern parent.

Having reached the age of maturity and become settled in what we may consider our life's work, is it not the tendency to let up a little in our quest for knowledge and experiences which make for better, broader and more valuable men?

Many a man has gained an enviable reputation among his associates and then due perhaps to demands placed upon his time has neglected the very thing that brought him success—his means of keeping better informed than those with whom he comes in contact.

No man can afford to lie down in his efforts to keep abreast of the times until he retires from his life's work. While in active work it behooves him to take time from his pleasures, his social activities or even his regular work if necessary to post himself on what is being done by the advanced thinkers and investigators of the day. The man who does not keep himself familiar with advances in his own industry will find himself severely handicapped many times, when obsolete equipment, for instance, is replaced. He becomes a reactionary, afraid to give a new idea a try-out. When he reaches that point his progress ceases. Lack of general information is just as detrimental.

With the coming of cooler weather, the lengthening of evenings and the natural desire to sit by the fireside, seems also to come the yearning for a more detailed knowledge of our own work and a broader insight into things of general interest. Why not during the coming months take the time necessary to inform ourselves more thoroughly on the things concerning our own work which we have always wished to know or advance our knowledge of things in general which have outgrown us during the scramble to make a living?

A Lesson from California

Although the curtailment of power supply in California, caused by the unprecedented water shortage, has worked a hardship on industry, it is likely that the costly experience may result in some good. It at least points out that a greater steam reserve is necessary if full advantage is to be taken of secondary water power development and if reliability of service is to be guaranteed. It has also shown that lack of standardization of generating frequencies is a great handicap at the time of an emergency. On the Pacific coast, 33 and 50 cycle equipment is in operation in addition to standard 60 cycle apparatus. During the present emergency it was found that this lack of standardization prevented the full use of system interconnections. So the situation in California is an engineering lesson for those power producing organizations which may, by even a remote stretch of the imagination, find themselves in a similar predicament.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Stoker Is Designed for Small Boilers

ONE OF THE interesting developments in the stoker field is a stoker for small boilers which has been designed by Joseph Harrington, designer of the Harrington chain grate stoker. Although at the present time the

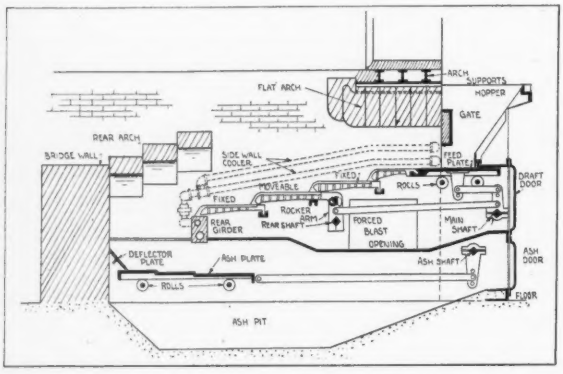


FIG. 1. COAL IS FED BY MOVEMENT OF RECIPROCATING PLATES

stoker has not been applied to house heating boilers, plans are under way to develop it in units as small as 3 sq. ft. of grate surface. Several applications have been made to horizontal return tubular boilers of 150 hp.

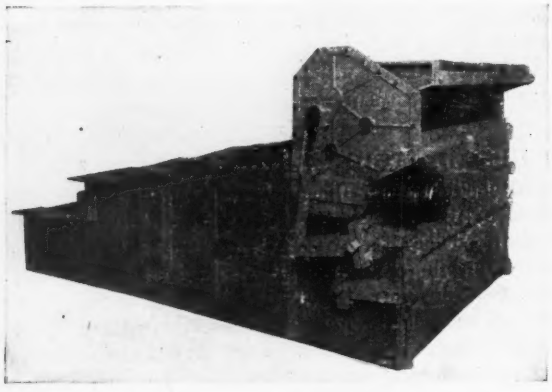


FIG. 2. STOKER IS BUILT FOR APPLICATIONS TO HOUSE HEATING BOILERS AND UP TO 250-HP. POWER BOILERS

As shown in Fig. 1 the base of the stoker is formed by a reciprocating plate carried on roller bearings. This plate has a travel up to 5 in.; the length of the travel determining the amount of coal fed. The grates are terraced or stepped and are arranged in series. The first set of grate bars rest upon and slide over the second step of the grate. The first and third grates have a forward and backward sliding motion (their action being simultaneous) and the second and fourth grates are stationary. By this motion the grate bars literally slide out from under the coal, the bed being disturbed only by its fall over the ends of the grate bars.

Directly under the ash opening at the rear is a plate which supports the ash as it falls from the fourth grate.

COMPARISON BETWEEN A SHAKING GRATE AND THE STOKER

	Hand Fired Shaking Grate Natural Draft	King Coal Stoker Forced Draft
Coal	Pocahontas	Ill. Screenings
Moisture	1.37	5.59
Ash	4.93	8.99
Volatile	22.03	31.98
Fixed Carbon	71.67	53.44
B.t.u.	14751	12625
Smoke observed	Practically Smokeless	Smokeless
CO_2 average	6.70	13.01
Horsepower, avg.	71.00	237.
Evaporation per lb. coal fired	6.35	9.11
Combustible in Ash (Wasted fuel).	45.81	12.06
Cost of evaporating 1000 lb. water.	.57c	.26c
Duration of test, hours	8.	8.

This plate has a reciprocating motion which provides a slow but definite travel of the ash toward the front. The ash opening is, however, sealed, at all times, against an inrush of cold air.

In the stoker either forced or natural draft may be used. The stoker drive is by means of a ¼-hp. motor although a water motor may be used if desired. The small amount of power required is explained by the fact that there are only three parts throughout the entire mechanism.

It is claimed by the engineers who have conducted tests on the stoker that western screening of high volatile content can be burned smokelessly and with an efficiency as high as 80 per cent. Other claims made for the device are: materially reduced fuel costs through ability to burn cheaper coal; reduced fuel consumption; reduction in volume of ash and elimination of smoke.

Several tests have been made on the stoker by John R. Moore Engineering Co., with Osborne Monnett and G. F. Gebhardt collaborating. One of these tests was run on a 150 h.r.t. boiler which was originally equipped with a shaking grate, and which the stoker supplanted. The results of this test are shown in the accompanying tabulation.

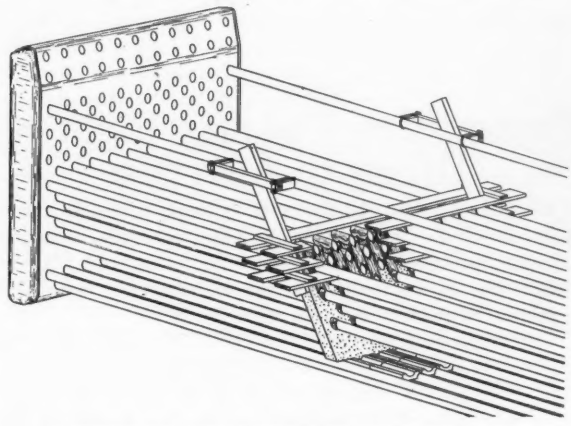
High points resulting from this test, which lasted 8 hr., were that the combined boiler and stoker efficiency was 66.1 per cent; that the boiler developed 234 hp.; that the CO_2 was 13.1 per cent; and that each pound of dry coal used evaporated 9.11 lb. of water from and at 212 deg. F.

This stoker is being marketed by the Stoker Sales Co., of Chicago, under the name of King Coal Stoker. Joseph Harrington is President of the organization.

Paper Tube Thimbles Used When Pouring Baffles

ONE DIFFICULTY which may be experienced with monolithic baffle walls, of the vertical type, is that of damage to the baffle when removing and replacing tubes. To overcome this, the Heine Boiler Co. now use a paper thimble, with walls $\frac{1}{16}$ in. thick, which is slipped over the tube and thus keeps the refractory from touching the tube. When the boiler is fired these tubes burn out and thus leave the tubes free to expand or to be removed without injury to the baffle.

These paper thimbles are used with a baffle cement called Refractite which sets hard on air drying and therefore does not depend upon high temperatures to harden it.



METHOD OF INSTALLING REFRACTITE BAFFLES

Its shrinkage is slight and when dry presents a hard and dense surface which should resist the impinging action of steam from soot blowers. Refractite is shipped dry and is made ready for use by mixing it with water.

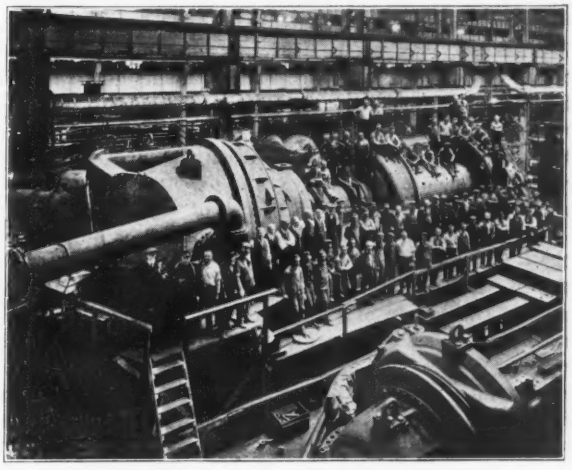
This baffle cement can best be installed at the time that the boiler is being tubed. For boilers which are tubed at the shop the baffle is built up as the work of tubing progresses. For large units which are tubed in the power plant the materials including wood forms and paper thimbles are shipped to the job and the baffles built up as the tubes are being placed.

Vertical baffle walls are built up as follows: the paper tubes are slipped over each tube before it is put in place. On each side of the tubebank a wood strip is clamped to the top and bottom tube. This locates the baffle and also serves as the form for the outside edge of the baffle. Boards 1 by 6 in. in size, with one edge beveled, if they are to be used with a sloping baffle, are passed between the horizontal rows of tubes and held against the side pieces already referred to. Pieces of wood ¼ in. thick with the ends notched to fit the tubes are placed against the 1 by 6 in. boards and between the tubes. This makes a form which is sufficiently tight for the use of Refractite, which is mixed stiff and is tamped into place after each row of tubes is placed.

This cement may also be used to build the upper or curtain baffle wall above the tube bank to separate the second from the third pass. Cast-iron reinforcing bars can be used to give added strength to these upper baffles much the same as steel bars are used for reinforced concrete building construction.

60,000-Kw. Unit for Crawford Avenue Station

SEVERAL features of interest are incorporated in the design of the General Electric 60,000-kw. cross-compound turbine, which has been built for the Crawford Ave. station of the Commonwealth Edison Co., Chicago,



THIS IS THE 43,000-KW. LOW PRESSURE TURBINE OF THE CROSS-COMPOUND 60,000-KW. UNIT

Ill. Resuperheating of the exhaust from the high pressure machine, before it enters the low pressure unit; two exhaust openings on the low pressure unit and the use of two vertical surface condensers are points which differ from ordinary practice.

Operating pressures for which the unit is designed

	High Pressure	Low Pressure
Rating, kw.	17,000	43,000
Speed, r.p.m.	1,800	1,200
Initial Press., lb. abs.	550	110
Initial Temp., Deg. F.	725	725
Exhaust pressure, lb. abs.	110	0.5
Stages	10	14
Weight, lb.	196,000	716,000
Overall length, ft.	58	62

In addition to the 17,000-kw. main generator, the high pressure side also drives a 2,000-kw. generator which furnishes the power supply for the auxiliaries. The low pressure side drives a 43,000-kw. generator and an exciter which supplies current for the three main generators.

The low-pressure turbine has no throttle or controlling valve, but the steam coming from the reheater to the turbine flows through an intercepting valve, which during normal operation is held open by oil pressure in a cylinder. This valve is closed by the action of an operating governor on the low-pressure turbine if the speed of this unit rises to 6 per cent above normal. If the speed drops, this valve is reopened. Steam-flow control to compensate for changing loads is taken care of by the operating governor and controlling valve on the high-pressure unit, so that the intercepting valve has no partial opening position.

It is expected that the unit will be in operation by October of this year.

Chemists to Consider Nation's Fuel Supply Problem

DISCUSSION of the nation's fuel supply will be a chief feature of the fall meeting of the American Chemical Society to be held at Cornell University, Sept. 8 to 13. Prof. S. W. Parr of the University of Illinois will lead round-table conferences on "The Storage of Coal and Spontaneous Combustion." Secretary Hoover's plans to relieve coal shortage and the report of the Coal Storage Committee of the American Engineering Council, of which Prof. Parr is a member, and of which W. L. Abbott, of Chicago, is chairman, will be dealt with.

Discussion on coal will be held under the auspices of the Gas and Fuel Section, of which Dr. R. T. Haslam, of the Massachusetts Institute of Technology, is chairman and O. O. Malleis, of Pittsburgh, secretary. All nations, according to chemists, are engaged in a worldwide hunt for new sources of fuel. The Gas and Fuel Section will meet jointly with the Industrial and Engineering Division in a symposium on absorption. The round-table discussion on coal led by Prof. Parr will be participated in by J. D. Davis, W. D. Langtry, N. R. Beagle, of Peoria, Ill. and W. H. Fulweiler, of Philadelphia.

Included in the tentative program are the following original papers:

Studies on Absorption of Naphthalene in "Gas Oil." D. L. Kowalke; The Rate of Flame Propagation and the Mass Law, F. W. Stevens; Radiation from Non-Luminous Flames, W. G. Lovell, R. T. Haslam, R. D. Hunneman; The Present Trend of the Manufactured Gas Industry, F. W. Steere; Combustion Relations within the Fuel Bed of a Gas Producer, R. T. Haslam, F. T. Entwistle, W. E. Gladding; Composition of the Volatile Matter Obtainable from Coke, H. J. Rose, G. C. Desy; True Measurement of High Gas Temperatures, R. T. Haslam, E. L. Chappell; Studies on Spontaneous Combustion of Coal, J. D. Davis, John F. Byrne.

Standardization Progress Shown by A. E. S. C. Report

THERE now exists the most wide-spread interest and activity in industrial standardization that has ever been shown, according to the new Year Book of the American Engineering Standards Committee. One hundred and fifty-two projects have been completed, or are under way, and in these various projects 235 national organizations, technical, industrial, governmental, are officially co-operating through accredited representatives. The number of the individuals serving under various sectional committees of the different projects is nearly 1100.

Of the projects which have reached an official status, 31 have to do with civil engineering and the building trades: 25 with mechanical engineering; 15 with electrical engineering; 4 with automotive subjects; 11 with transport; 1 with ships and their machinery; 14 with ferrous metals; 15 with non-ferrous metals; 12 with chemical subjects; 2 with textiles; 5 with mining; 5 with the wood industry; 1 with the paper and pulp industry; and 11 projects with topics of a miscellaneous or general character.

Co-operation in joint activities between Mr. Hoover's Division of Simplified Practice and the American Engineering Standards Committee has steadily increased. In general the work of the Committee is concentrated upon standardization projects which involve technical considerations, while the Division of Simplified Practice concentrates upon such eliminations as it is possible to carry out from a consideration of statistical production data alone, or as stated in the book on trade association activities issued by the Department of Commerce, "the layman can proceed successfully with a simplification program, while it would be impossible for him to consider seriously standardization problems by himself."

The Year Book may be secured by addressing the American Engineering Standards Committee, 29 West 39th St., New York City.

Commission Upholds Right of Utility to Advertise

SHALL a public utility company be permitted to spend money for advertising? This was the question recently brought up in Connecticut, when the City of Stamford, represented by its mayor, entered a complaint against the Stamford Gas & Electric Co.

It seems that the public utility in that city, in order to counteract a program of political innuendo, had used the newspapers to present its side of the case. The situation was some what peculiar because the mayor of the city owns the newspaper in which most of the advertising was placed. The mayor, in a dual role, was denouncing the grasping monopoly for advertising, and on the other hand was pocketing the checks in payment for that advertising.

In its decision the commission stated that: "The experience and observation of this Commission has been that frequent complaints by patrons in matters relating to utilities are due to the omission of the utility to provide intelligent information.

"This commission has always advocated a proper amount of publicity on the part of utility companies in order that their patrons may be informed in a general way as to operating and financial conditions as affecting the rate payers.

"A fair and frank statement by a utility on controversial questions will assist in maintaining a relationship of good will and co-operation between the company and its patrons. While there is, of course, a financial limit to which a utility should not go in the matter of publicity, the Commission does not find in the instant case many facts which would warrant its intervention. For the reasons stated herein, the petition is dismissed without further action on the part of the Commission."

Excess Water Power to Generate Steam

COAL savings estimated at 3000 T. a year are expected to result from the installation of an electric steam generator which is to be installed by the St. Croix Paper Co. at Woodland, Me. Improved power factor and utilization of spring and fall high water are looked forward to from other up-to-date electrical machinery now being installed.

The hydroelectric plant of this company is on the St. Croix River and is twelve miles from the company's mill. A General Electric, 3360-kw., 2400-v., vertical waterwheel generator is now being installed to be used as a spare unit and to permit the utilization of high water in the spring and fall for the generation of excess power. This excess power may be used either for the making of wood pulp or for running the electric steam generator. Wood pulp made in this manner during the flood season will be stored away as dry pulp laps and be made into paper during the dry summer and fall months.

Officials of the St. Croix Co. and General Electric Co. engineers estimate that the new generator may produce as high as 15,000,000 kw.-hr. excess power at high water periods, with a normal rainfall. By putting this power into the electric steam generator, they expect a saving of approximately 3000 T. of coal a year. The steam generator is to be located in the boiler house and will be piped into the main steam line, supplementing the coal fired boilers. Steam necessary to heat the mills on Sundays and holidays, when the motor load is shut off, will come from the electric steam generator and the load curve of the mill will be ironed out by having the steam generator take up the variations in electrical load on the mill from time to time. An 1800 hp., 2200 v., synchronous grinder motor to be direct coupled to pulp grinders is also being installed. Present wood grinders at the paper mill are part motor driven and part waterwheel driven, and are of the pocket type. The new motor will also drive pocket grinders, but will be so arranged that magazine grinders may be installed later. In addition to the necessary switchboard equipment, a 6000 kv. a. transformer has been ordered to step down the voltage from 33,000 v. to 6600 v. for use in the electric steam generator. The electrical machinery already installed was made by the General Electric Company, which is also supplying the additional electrical equipment.

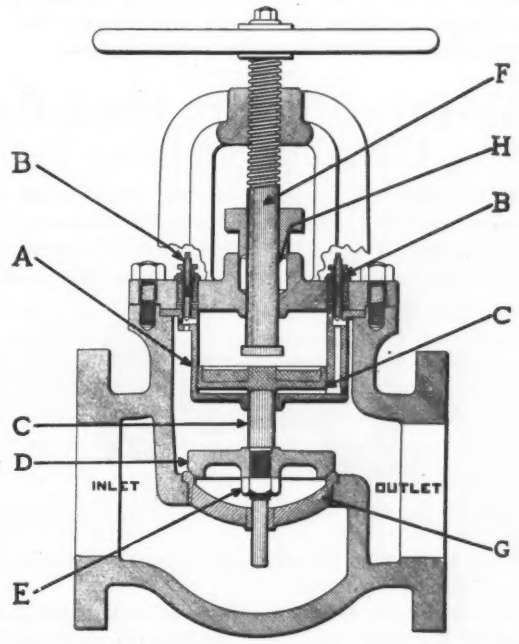
Three definite results are expected by the St. Croix officials: Power factor correction by the synchronous grinder motor; the utilization of otherwise waste energy by working up raw material in advance of requirements, and the substitution of a certain amount of electrically generated steam for the steam ordinarily produced by burning coal.

IN RECOGNITION of the invention and development of "a process and apparatus for the deaeration of liquids," the Franklin Institute of the State of Pennsylvania, at Philadelphia, has honored W. S. Elliott, president of Elliott Co., with the award of the Edward Longstreth Medal and Diploma. The Edward Longstreth Medal is awarded by the Franklin Institute for inventions of high order and for particularly meritorious improvement and developments in machines and mechanical processes.

New Stop and Check Valve Brought Out

WHERE two or more boilers are connected to a common steam header the necessity for stop and check valves as a safety and protective device has been well established. Moreover the service requirement, which demands a valve which will function properly as the boiler comes on the line and which will operate with certainty when emergencies arise, have led to much research in the development of such valves.

One of the new stop and check valves which has recently been brought out is a development of the Scott Valve Mfg. Co., of Detroit. This valve, as will be noted from the accompanying sectional view, contains a piston,



PISTON AND CUSHIONING PORT VALVES REDUCE POSSIBILITY OF SHOCK DUE TO SUDDEN PRESSURE CHANGES

B, and dash pot, A, placed in the outlet side of the valve casing. Protection against shock is afforded by the cushioning port valves, B. The valve disc, D, is of cast iron while the seat and disc guide, G, are of bronze. F is the main valve stem and packing space is provided at H. Since the piston and dash pot are in contact with the header steam, when the valve is closed, expansion strains due to wide temperature variations are eliminated.

Middle West Utilities Acquires Indiana Waterpower

CONTROLLING INTEREST in the Indiana Hydroelectric Power Co. has been acquired by the Middle West Utilities Co., according to a recent announcement. The latter company has had a substantial proprietary interest in the Indiana company since the latter's organization in 1921 for the purpose of developing the hydroelectric properties on the Tippecanoe River, but only through the present deal was actual control obtained.

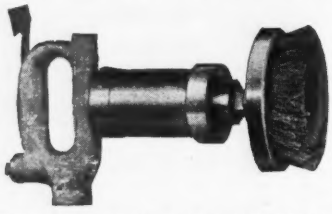
Since last year the Hydroelectric Co. has had its initial

hydroelectric development at Norway, Ind. in operation. The installed capacity of this station is 8,500 hp. and the energy output is fed into the transmission systems of the Interstate Public Service Co. in Indiana and the Central Public Service Co. in Illinois. In addition to the Norway property, sites for further developments on the Tippecanoe River aggregating about 21,000 hp., are owned at Oakdale and Springboro.

Plans have been announced for the immediate development of the Oakdale site, 10 mi. down the river from the Norway plant. The new station will have an installed generating capacity of 14,000 hp. The energy generated will be purchased by the Central Illinois Public Service Co. and the Interstate Public Service Co. as in the case of the output of the Norway hydro-station. Work has already started, and it is estimated that the plant will be ready to generate electric energy for the heavy fall load next year. The Interstate Public Service Co. will operate the new development, as it now does the Norway station.

Air-Driven Rotary Brush for Cleaning Surfaces

IN ORDER to facilitate the removal of rust, paint and scale from flat surfaces the Liberty Manufacturing Co., of Pittsburgh, Pa. has developed an air-driven rotary brush. The air motor is a somewhat similar type to those



ROTARY BRUSH IS MADE UP OF STEEL WIRE BRISTLES

used on boiler tube cleaners and operates on an air pressure of from 50 to 75 lb.

It will be noted from the illustration that the motor is provided with a valve for controlling the air, located in the handle and actuated by a trigger. The brush used is 5 in. in diameter and is made up of steel wire bristles. The design of the brush is such that it will not lose its bristles, although after the bristles have worn down the brush can be replaced. The complete outfit weighs about 9 lb. and has an overall length of 12 in.

Merger of Colorado Companies Contemplated

WITH THE merging of the Colorado Power Company and the Public Service Company of Colorado, for which a proposal will be placed before the stockholders of both companies at meetings Sept. 3, a $40,000,000 organization would be completed that would own the two largest hydroelectric generating stations in the state as well as the new $12,000,000 Valmont plant near Boulder, Colo., which is nearing completion. With the completion of the merger, proponents of it say, the company will be able to furnish a total of 107,000 hp. of electricity from nine steam plants and four hydroelectric plants to consumers throughout the northern half of Colorado and part of Wyoming.

Distributing its power over 355 mi. of joint transmission lines and 1500 mi. of consumer-branch lines, over a territory with an estimated population of 425,000, the proposed company would enjoy many advantages not possible while the two companies serve the same territory, as at present.

The Public Service Co. was formed last year in a merger of the Denver Gas & Electric Light Co. and the Western Light & Power Co. With two steam electric plants in Denver, one near Lafayette, Colo., and one in Cheyenne, the company supplies gas, electricity and heat to Denver and Cheyenne, and electric light and power to practically all of Northern Colorado. The first unit of the Valmont plant, which will furnish 27,000 hp., will be completed next year. With the completion of the other units the plant will be capable of development to furnish 270,000 hp.

The Colorado Power Co. which operates the two largest hydroelectric plants in the state, one near Glenwood Springs and the other near Boulder, supplies electric light and power in the mining regions west of Denver and in other parts of the state. Its physical assets approximate $18,000,000, and it operates several small hydro plants as well as several steam plants in different parts of the state.

News Notes

ALLIS-CHALMERS MANUFACTURING CO., Milwaukee, Wis., has received an order for the new station of the California Oregon Power Co., Medford, Ore., embracing two vertical-shaft Francis turbines rated at 20,000 hp. under 140-ft. net head, at 171 r.p.m. of the circular-section, plate-steel, spiral-casing type and with the concrete type of White hydraucone. The equipment also includes the governors and the oil-pumping system. Westinghouse generators of the two-bearing type will be used, for which Allis-Chalmers will furnish cast iron supporting barrels between the speed ring of the turbine and the stator of the generator so as to insure the alinement of both parts. It is expected that this plant will furnish energy by May 1, 1925, the whole output being contracted for delivery to the power system of the Pacific Gas & Electric Co., San Francisco.

ACQUISITION of additional plants by the Link-Belt Co., and the considerable extension of its lines and business, during the past 5 yr. have prompted Mr. Charles Piez, president of the company, to suggest to the Board of Directors some changes in the organization, which, through a partial decentralization of functions, will reduce the burdens on the present officers, and will open the way for a continuation of the policy of expansion. The company is now operating nine plants and 25 sales offices, and supreme executive and financial authority has heretofore been delegated by the Board of Directors to the president.

The chairman of the Board was made the chief executive officer of the company and an Executive Committee of four was created to act in an advisory capacity to the officers. Mr. Piez was elected Chairman of the Board and Chairman of the Executive Committee; Alfred Kauffman, newly elected president, Staunton B. Peck, senior vice-president, and Thomas B. Marston, a member of the Board of Directors, were selected as the other three members of the Executive Committee. Alfred Kauffman, second vice-president of the company, was elected president.

W. H. NICHOLSON & Co., Wilkes-Barre, Pa., has changed the name of its line of eliminators, separators and traps from "Wyoming" to "Nicholson."

TERRE HAUTE, IND. WATER CO., is installing one 200-hp. Stirling boiler and expects to tear out two more boilers and replace with boilers of this type. The company also installed a 10,000,000-gal. turbine pump furnished by Dravo-Doyle Co., Pittsburgh, Pa., and one new tile stack 208 ft. high, 12 ft. in diameter at the base and 7½ ft. inside diameter at the top.

WARREN WEBSTER & Co. of Camden, N. J., announces the opening of two new branches of Butte, Mont. and Albany, N. Y. The Butte office is in charge of T. L. Sullivan, formerly of the Anaconda Copper Mining Co. and more recently with the Montana State Engineering Department. This office will have charge of all business in the state. The Albany office is in charge of Horace A. Bond, for many years service engineer with the New York City branch.

H. L. WOOLFENDEN has joined the Scott Valve Manufacturing Co. of Detroit, Mich., and will have charge of sales promotion. Mr. Woolfenden is a graduate mechanical and electrical engineer, having received both degrees from the University of Michigan. After several years spent as a consulting engineer in Detroit, he went to Denver in 1901 and engaged in engineering and contracting, later becoming associated with the Allis-Chalmers Manufacturing Co., Mr. Woolfenden while district manager at Denver, had charge of all sales and engineering work in the Rocky Mountain District.

WILLIAM CONSTABLE Co., Providence Bldg., Duluth, Minn., will henceforth represent the De Laval Steam Turbine Co., of Trenton, N. J., having purchased the H. J. Rich Co., the former representative. The territory covered by the Wm. Constable Co. includes Northern Minnesota and Wisconsin and the entire Northern Peninsula of Michigan. Mr. Constable was chief mechanical and electrical engineer for the Republic Iron & Steel Co., of Duluth, for the past 5 yr., and previously was connected with the General Electric Co. in the mining, locomotive and steam turbine department at Duluth.

JOHN H. DUNLAP, secretary of the American Society of Civil Engineers since 1922, died on July 29, 1924, at the Presbyterian Hospital in Chicago from injuries received in a railroad wreck at Buda, Ill., June 30, while returning from the fifty-fourth annual convention of the Society in Pasadena, Cal.

FIVE NATIONAL SOCIETIES will participate in Management Week October 20-25, 1924, in seventy-five states and cities throughout the United States and Canada. An official representative of each Society has been appointed to serve on a national committee on arrangements. The personnel of this committee is as follows: Henry Bruere, the representative of the American Management Association; Sterling H. Bunnell, representing the American Society of Mechanical Engineers; W. H. Leffingwell, representing the Taylor Society; E. M. Robinson, representing the Society of Industrial Engineers, and C. R. Stevenson, representing the National Association of Cost Accountants.

WHAT HAS HAPPENED IN SAFETY during the past year will be the key-note of the Thirteenth Annual Safety Congress of the National Safety Council which meets in Louisville, Sept. 29 to Oct. 3. The story of progress will be related by speakers of national and international prominence, will be shown vividly by exhibits, motion picture films and lantern slides and will be demonstrated in the daily sectional sessions and general sessions of the greatest Safety Congress in history. More than 4000 industrial plants, and Community Safety Councils in 60 American cities, members of the National Safety Council, will be represented at the Congress.

WILLIAMS GAUGE Co., Pittsburgh, Pa., manufacturer of steam specialties, has awarded The Austin Co., Pittsburgh, a contract for the design and construction of a machine shop and office building 60 by 120 ft. The Austin Co. will make all purchases and handle construction.

THE NEW HIGH BRIDGE POWER STATION of the Northern States Power Co. at St. Paul, Minn., has gone into operation following the completion of the first 40,000 hp. steam turbine unit. Work on the second 40,000 hp. unit is well advanced.

NATIONAL BISCUIT CO., MARSEILLES, ILL., is installing two Babcock & Wilcox boilers of 150 hp. each and one Allis-Chalmers Corliss engine and generator. They now have nine 150-hp. boilers and this addition gives them a 1650 hp. boiler plant. Geo. W. Sterrett is the superintendent.

THE VILLAGE OF EPHRATA, PA., is just completing a municipal power plant which went into operation in August, with S. L. Sharp in the capacity of chief engineer. The equipment includes one 1000-kw. General Electric Co. turbine, Schutte & Koerting condenser and rebuilt marine type boilers, totaling 1000 hp.

CITY OF LOGAN, UTAH, is now completing the work of enlarging its hydro-electric plant in Logan Canon by the installation of two Westinghouse 875-kv.a. turbines. This will make four units in the plant, the original equipment being two Westinghouse 250 kw. turbines. In this canon in a distance of 5 mi. water is turned over three times. After it is returned to the stream-bed from the tail-race of the Logan municipal plant, 1½ mi. down the canon, it is picked up and conveyed 3 mi. by flume to the plant of Utah Power & Light Co., where 5000 kw. are generated, and ½ mi. further down the water is again picked up and by the Utah Agricultural College, where 500 kw. are generated.

A PERMIT AUTHORIZING the Puget Sound Power & Light Co. to begin work on its Eden power site on the Baker River in Skagit County, Wash., has been issued by Marvin Chase, supervisor of hydraulics. The development involves construction of a hydro-electric plant with an estimated capacity of 63,000 hp. at a cost of about $3,500,000 and the formation of a reservoir capable of impounding 50,000 acre feet of water at an estimated cost of $1,500,000. The company will be allowed to appropriate 4000 second feet of water from the river for operating the generators at the plant. The diversion dam, which will be of concrete, will be 235 ft. high, 325 ft. wide on top and 100 ft. on the bottom. The reservoir will flood 1600 acres, the maximum depth being 200 ft. and the approximate mean depth 31 ft. The power plant and other improvements will be constructed of concrete. Construction work is to begin within a year, the permit states.

A 6000-HP. WATER POWER PLANT is being constructed for the City of Dothan, on the Choctawhatchee River, in Geneva County, Alabama. It is 21.5 mi. from Dothan in a straight line and about 8 mi. by road from Hartford, Alabama. A concrete dam 300 ft. long and a dirt dam 3000 ft. long are being built. The power plant will contain two Worthington water wheels 1600 hp. each, two General Electric 1400-kv.a., 3-phase, 2300-v., 60-cycle, generators with direct connected exciters. Provision will be made for two additional duplicate units. Power will be transmitted to Dothan at a potential of 44,000 v. The line has already been completed and is carrying power from the Dothan steam plant to the contractor, J. G. Scott & Co., for construction purposes. It is expected that the work will be completed about May, 1925. The Ludlow Engineers, Inc., of Winston-Salem, N. C. are the consulting engineers in charge of the design and construction.

Books and Catalogs

TULLY'S HANDBOOK, originally by Henry C. Tully, but revised and enlarged by James F. Hobart; 3 volumes, 1155 pages, illustrated, size 6 by 9 in., 7th edition, New York, 1924.

When Henry C. Tully first brought out his handbook in 1900, he stated that it was his object to prepare a work to which the practical engineer could refer, with confidence, regarding every branch of his profession. An attempt has been made to adhere to this broad purpose, consequently the seventh edition of this handbook is published in three volumes, which cover the care of steam and electrical equipment from all angles.

It has been difficult during the weeding out process which has been required as the successive editions have been issued, to keep the old time atmosphere from pervading the handbook. It may be stated, however, that Mr. Hobart in his revision has accomplished this result successfully. There are a few spots in the books, which, in the light of present day practice, seem somewhat antiquated, although most of the obsolete material has been eliminated. Among new topics that should be mentioned are: Modern methods of steam boiler operations, balanced draft, combustion control, CO_2 determination and other subjects. Modern steam engines, including the uniflow, and turbines have been described and a chapter has been added dealing with the operation of modern internal combustion engines. Improved steam appliances and fittings have been explained thoroughly and their uses and economies exemplified. Modern steam boilers, furnaces and stacks have been fully discussed, and a chapter on flue gas analysis is included. A chapter on power transmission gives the main points of belt, rope and gear transmissions. Several chapters devoted to electric power and lighting offer fundamental data required by the engineer. A chapter on lamps has been added, and also on data on heating and ventilation.

Two new and particularly valuable additions have been made. The first is a section entitled "How and Why" which gives a great number of kinks helpful to the engineer. The second is a collection of "Handy Tables" which gives the engineer the information which he must always have available for quick reference.

UNION IRON WORKS has recently issued an interesting booklet, describing in detail the design and construction of its new Universal boiler of the self-contained return flue type. The booklet shows interior and exterior views as well as sections through the boiler and a table gives data on all dimensions of importance. The universal boiler is made in sizes from 25 to 150 hp. and is particularly adapted to installations where only small floor space is available. Copies may be had by addressing the Union Iron Works, Erie, Pa.

"NATIONAL" PIPE FOR POWER PLANTS, is the title of a bulletin which has been published by the National Tube Co., Frick Building, Pittsburgh, Pa. The first part of the bulletin is taken up with a discussion of the general problems involved in the use of piping in power plants, including the selection of a system, classification of pipe, weights of pipe for various lines and other such details. Then follows a section on the specific advantages of National pipe which shows the physical properties of this particular brand. Then follows an instructive article on the use of welding in power plant piping; standard specifications for power piping; diagram and color schemes for piping. The balance of the bulletin is made up of tabulations, giving the weights, dimensions and other specifications of pipe and then some general tables on the properties of steam.

THERMOLITH, the All-Temperature Fire Cement is the title of a new publication by the Harbison-Walker Refractories Co. It is bulletin on the value and method of applying Thermolith in the various industries in which it is used, together with tests and data relative to its performance.

UNITED STEAM-JET CONVEYORS is the title of a bulletin now being distributed by the United Conveyor Corporation, 15 Old Colony Bldg., Chicago, Ill. It discusses in detail the use of steam jet conveyors and also describes a line of ash storage tanks, coal and ash gates, and air tight doors which are manufactured by this organization.

CENTRIFUGAL PUMPS AND PUMPING UNITS, bulletin No. 1632-G is a revised edition of a previous bulletin on this subject which has just been brought out by the Allis-Chalmers Mfg. Co., of Milwaukee, Wis. In addition to describing the complete line of pumps, considerable information is given on the application of centrifugal pumps, as well as instructions for their installation and operation.

SEWAGE PUMPS are described in a pamphlet from the De Laval Steam Turbine Co., Trenton, N. J. These pumps are of the single stage double suction type. For some conditions they are fitted with special open impellers, which run close to removable side plates in such a way that the knife-like edges of the impeller blades will shear or cut stringy material. Due to the close clearance employed and the smooth surfaces of the side plates, the efficiencies obtained are said to be practically as high as those shown by enclosed impellers for similar heads, capacities and speeds. The impellers are made of bronze and the shaft is encased in bronze sleeves, which extend out through the packing glands. In addition stationary guide sleeves supported by the pump casing prevent rags and strings from wrapping around the shaft. Where there is an exceptionally large amount of solid matter in the water, a flushing connection is provided on the casing cover, so that water can be forced backward through the impeller into the suction.